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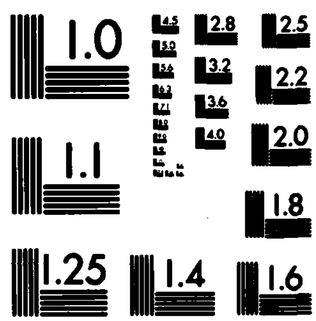

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**AQUATIC PLANT CONTROL
RESEARCH PROGRAM**

MISCELLANEOUS PAPER A-86-2

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18-21 NOVEMBER 1985
ATLANTA, GEORGIA

June 1986
Final Report

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The 20th Annual Meeting of the US Army Corps of Engineers Aquatic Plant Control Research Program was held in Atlanta, Georgia, on 18-21 November 1985, to review current research activities and to afford an opportunity for presentation of operational needs. Papers presented at the meeting are included in this report. The general theme of this 20th Annual Meeting and the papers presented was a retrospective look over the past years of the program and a look at "where do we go from here."

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PREFACE

The 20th Annual Meeting of the US Army Corps of Engineers Aquatic Plant Control Program was held in Atlanta, Georgia, on 18-21 November 1985. The meeting is required by Engineer Regulation (ER) 1130-2-412 paragraph 4c and was organized by personnel of the Aquatic Plant Control Research Program (APCRP), Environmental Laboratory (EL), US Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss.

The organizational activities were carried out and presentations by WES personnel were prepared under the general supervision of Dr. John Harrison, Chief, EL. Mr. J. Lewis Decell was Program Manager, APCRP. Mr. W. N. Rushing, APCRP, was responsible for planning and chairing the meeting. Mr. E. Carl Brown was Technical Monitor for the Office, Chief of Engineers, US Army.

Ms. Jamie W. Leach of the WES Publications and Graphic Arts Division (P&GAD) edited this report. Ms. Loriece M. Beall of P&GAD designed and composed the layout.

Director of the WES at the time of the meeting was COL Allen F. Grum, USA. Technical Director was Dr. Robert W. Whalin.

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20th Annual Meeting
US Army Corps of Engineers
AQUATIC PLANT CONTROL RESEARCH PROGRAM

Atlanta, Georgia
18-21 November 1985

MONDAY, 18 NOVEMBER 1985

10:00 a.m. -5:30 p.m.	Registration—Paces Court
6:30 p.m.	Reception—Ashford Room

TUESDAY, 19 NOVEMBER 1985
General Session, Paces East

8:00 a.m.	Registration Continues
8:30 a.m.	Call to Order and Announcements —W. N. Rushing, Waterways Experiment Station (WES), Vicksburg, Mississippi
8:35 a.m.	Welcome —BG C. E. Edgar III, Commander, USAE Division, South Atlantic Atlanta, Georgia
8:45 a.m.	Introduction and Comments —J. Lewis Decell, Manager, Aquatic Plant Control Research Program (APCRP), WES, Vicksburg, MS —Robert W. Whalin, Technical Director, WES —E. Carl Brown, Technical Monitor, APCRP Construction-Operations Division, Natural Resources Management Branch, (OCE), Washington, DC —H. Roger Hamilton, Chief, Resource Analysis Group, Environmental Laboratory, WES (OCE Technical Monitor 1975-1980)
9:30 a.m.	Retrospective Overview, APCRP 1975-1985 —J. Lewis Decell, WES
10:00 a.m.	In the Beginning . . . —Harold L. Blakey, OCE (Retired) —Julian J. Raynes, USAE Division, South Atlantic (Retired)
11:00 a.m.	Aquatic Plant Control Research Program Technical Area Perspectives Biological Control Technology Development —Ed A. Theriot, WES Chemical Control Technology Development —Howard E. Westerdahl, WES
12:00 noon	LUNCH

1:30 p.m. APCRP Technical Area Perspectives - Continued
Computer-Aided Technique Development
—Tommy D. Hutto, WES
Ecological Studies
—John W. Barko, WES
Mechanical Control Technology Development
—Katherine S. Long, WES
Integrated Strategy Development
—Tom L. Hart, WES

4:00 p.m. ADJOURN for the day

WEDNESDAY, 20 NOVEMBER 1985
General Session Continued
Paces East

8:00 a.m. Corps Division/District Operations Perspectives
Lower Mississippi Valley Division, New Orleans District
Lower Mississippi Valley Division, Vicksburg District
—Julie Marcy
New England Division
—Susan Brown
North Atlantic Division, Baltimore District
—Glenn Earhart
North Pacific Division, Seattle District
—Bob Rawson
—John Wakeman
South Atlantic Division, Charleston District
—John Carothers
South Atlantic Division, Jacksonville District, Aquatic Plant Control Operation Support Center
—Jim McGehee*
South Atlantic Division, Mobile District
—Mike Eubanks
South Atlantic Division, Mobile District, Lake Seminole
—Joe Kight
South Atlantic Division, Savannah District
—Mark McKevitt
South Atlantic Division, Wilmington District
—Chuck Wilson
Southwestern Division, Galveston District
—Joyce Johnson
Southwestern Division, Tulsa District
—Loren Mason
Southwestern Division, Fort Worth District
—Edward Moyer

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* No paper provided for inclusion in the Proceedings.

12:00 noon	LUNCH
1:30 p.m.	Open Forum - "Where Do We Go From Here?" —Moderator, J. Lewis Decell, WES
3:30 p.m.	Summation —J. Lewis Decell, WES
4:00 p.m.	ADJOURN

THURSDAY, 21 NOVEMBER 1985
Greenbrier Room

8:30 a.m. -12:00 noon	1987 Civil Works R&D Review, R&D Directorate, OCE (Corps of Engineers Representatives Only)

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20th Annual Meeting
US Army Corps of Engineers
AQUATIC PLANT CONTROL RESEARCH PROGRAM

Atlanta, Georgia
18-21 November 1985

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CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
acres	4046.873	square metres
feet	0.3048	metres
gallons (US liquid)	3.785412	cubic decimetres
inches	25.4	millimetres
miles (US statute)	1.609347	kilometres
pounds (mass)	0.000112	kilograms
tons (2,000-lb mass)	907.1847	kilograms
yards	0.9144	metres

20th Annual Meeting
US Army Corps of Engineers

AQUATIC PLANT CONTROL RESEARCH PROGRAM

INTRODUCTION

The Corps of Engineers (CE) Aquatic Plant Control Research Program (APCRP) requires that a meeting be held each year to provide for professional presentation of current research projects and review current operations activities and problems. Subsequent to these presentations, the Civil Works Research and Development Program Review is held. This program review is attended by representatives of the Civil Works and Research Development Directorates of the Office of the Chief of Engineers; the Program Manager, APCRP; and representatives of the operations elements of various Division and District Engineer Offices.

The overall objective of this annual meeting is to thoroughly review Corps aquatic plant control needs and establish priorities for future research, such that identified needs are satisfied in a timely manner.

The technical findings of each research effort conducted under the APCRP are reported to the Manager, APCRP, US Army Engineer Waterways Experiment Station (WES), each year in the form of quarterly progress reports and a final technical report. Each technical report is given wide distribution as a means of transferring technology to the technical community. Technology transfer to the field operations elements is effected through the conduct of demonstration projects in various District Office problem areas and through publication of Instruction Reports (IR), Engineering Circulars (EC), and Engineering Manuals (EM). Periodically, results are presented through publication of an APCRP Information Exchange Bulletin which is distributed to both the field units and the general community. Public-oriented brochures, movies, and speaking engagements are used to keep the general public informed.

The printed proceedings of the annual meetings and program reviews are intended to provide Corps management with an annual summary to ensure that the research is being focused on the current operational needs on a nationwide scale.

The contents of this report include the presentations of the 20th Annual Meeting held in Atlanta, Georgia, 18-21 November 1985.

RETROSPECTIVE OVERVIEW, 1975-1985

by
J. Lewis Decell*

1975-1976

Prior to 1975 several events took place that were to set the stage for the structure of the Aquatic Plant Control Research Program (APCRP) as we know it today. Until approximately 1973-74, the Program was administered by the Planning Division of the Office, Chief of Engineers. In 1973, the Chief of Civil Works, OCE, directed that the responsibility for the administration of the Aquatic Plant Control Program be assigned to the Recreation-Resource Management Branch of OCE. Today, this branch is the Natural Resources Management Branch. At the same time, the Waterways Experiment Station was designated as the Corps' lead laboratory for aquatic plant control (APC) research. With this designation came the responsibility for management of the research program. Subsequent to these changes, sometime in late 1974, a meeting was held in OCE to enable the Chief of Civil Works to provide guidance for the Program. He concluded with the statement that we were to "bring this program up commensurate with the national problem (if there is indeed a national problem), or give it to the states that have the problems." In addition, he directed that the Program be reorganized to become more operationally oriented. Almost exactly 30 days after the meeting, he telephoned the APC Technical Monitor and asked "What have you done to turn the APC Program around? The Technical Monitor had no answers, but was gracious enough to share the question with the new research program manager—yours truly. It was evident that it was past time to "roll up our sleeves and get to work." The transition had already started.

Many meetings took place in a very short period of time. The space between Washington, D.C., and Vicksburg, Miss., was of minor concern, to say nothing of the distance between Vicksburg, Jacksonville, Fla., and New Orleans, La. While one or two other Corps Districts had minor involvements in the APC Program, these two Districts truly represented the state of the art in operational capability. We also visited State and local agencies in Florida. Brush fire control was the order of the day.

For the operational aspects we turned to the Jacksonville and New Orleans Districts. We were quickly educated. We learned how they conducted their business, justified their funds, and more importantly, the capabilities they wished they had available to them.

Research at this time could best be described as having so little continuity as to defy attempts to assess the state of the art. Several efforts were ongoing, funded by the Corps, but it was difficult to relate the direction of the research to some operational need. The realization that the most crucial problems faced at that time

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* US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

were management, and not biological, problems would be at least 2 years away. It would be many years before the concept of management began to be reflected in our manner of doing business. Given the guidance, we began to talk to everyone "in the business" trying to formulate a future direction for our efforts.

For the research aspects, we visited each researcher at each university and agency and asked two basic questions: "What problem are you trying to solve with the conduct of this research," and "what will be the usable form of the technology that is developed?" In almost every case, the answers were insufficient. The questions were unfair to the audience to which they were directed, but they were both necessary and certainly enlightening. Finally, in about late 1975, during the last of the annual meetings organized by OCE, the lid began to lift open on the proverbial "can of worms."

The Office of Research and Development of OCE required that a 5-year research and development plan be written. The formulation of this plan, while basically an administrative burden, proved to be of value in other ways. It forced us to come to grips with not only how each of our research efforts must be related to solving a real-world problem, but equally important how they are related to each other.

Based on our communications with the operational contacts and the research contacts, we established what we thought were far-sighted goals. With the exception of one case, we achieved every established 5-year objective in 2 short years. Not far-sighted enough? Maybe. Better than we thought we were? Probably, but not that good. Our reward for this achievement was a directive to produce another 5-year plan. Now we had to really analyze how this happened. Progress is important, but we seemed to be impeded by our own progress.

In looking back, I realize that while we were dealing with the complexity of the problem of organizing our efforts, we failed to recognize the basic nature of the technology problems we needed to solve. While we went about our micromanagement, the big picture passed by us unnoticed. In spite of ourselves, the scientists had completed their first set of tasks.

During this period the number of actively participating CE Districts grew from two to five, representing three Divisions.

1977-81

A new 5-year plan to cover the period 1977-1981 was formulated, submitted, approved, and placed on the shelf. Served the purpose again. Those doing the research eventually fell into two distinct groups. One group said "I've got something you need, and if you don't want to pay me for it, I'll go home." The other group said, "It is very gratifying to see the results of my research being applied to the solution of a problem—thank you." Most of the latter group are still with us today, and their success has bred success. The momentum kept building and the new direction looked progressive. But realistically only for the research effort. At this point, we had done essentially nothing for the operations problems. But fortunately, the weed populations remained static while we got our act together. They must have, if there was any relationship between funding levels and problems—I'll get back to that later.

It was during this time of the Program that four facets of a philosophy began to emerge. One Websterian definition of philosophy is: "a system of motivating beliefs, concepts and principles." As a research manager, the value of a consistent philosophy became apparent. I quickly learned that in the cases where the long-range research objective was to either improve an existing capability or provide a new capability, sustaining our effort was not a problem. The objectives were the key. They proved to be the thread that held things together in times of reevaluation. They were the checklist for reference that made the decisions easy and sustained the confidence that there was indeed a light at the end of the tunnel.

In early 1977, it was becoming more evident that the research program would soon be ready to "throw the ball." My concern was that there would be no one to catch it. We suggested that the annual meeting contain a time for the operations people to present their problems, and thus formalize the two-way communications. The first facet of philosophy was: *"continual communications between operations and research must be continually practiced."* I recommended to the Office of Research and Development that the Annual Civil Works Program Review be held in conjunction with this meeting. This resulted in two advantages: first, it provided the OCE decisionmakers with a complete exposure to both elements of the Program in a very timely manner; and second, the operations representatives were readily available to attend the review and provide their much needed input.

Another leg of the communications was established. During this time period we began to gain momentum on both sides of the house to the point that most of the time we actually acted as a team. Once both sides began to understand the operational problems in terms we could relate to research objectives, we began to reinforce each other and gained support.

The second facet of philosophy emerged: *"the final design of a truly need-oriented research effort results from narrow-minded discussions between one researcher and one operations person, both of whom always know their business."*

As the momentum of the new direction increased, and the shape of things to come became clearer, outside agencies and universities began to submit proposals for conducting research. This appeared encouraging because we now had someone else interested in solving our problems. That must have been the motivation. The fact that the budget had finally started to consistently increase was probably not a factor. What readily became clear was that we had the old "square peg in the round hole" problem — and it became an increasingly difficult problem. We could run the risk of conducting the research program as a "vest pocket operation."

In searching for a way to provide focus to those wanting to participate in the Corps' Program, we now had to meet our responsibility to clearly define our operationally oriented research objectives to the academic world, without discouraging them. The third facet of the emerging philosophy was: *"we fund our research — not theirs."* This required us to maintain a continual self-awareness of the objectives and the need to bring together these researchers with our operations elements for a clearer view of the operation problems. This meeting serves that need very well.

Using the organizational structure of the research program as an indicator,

certain events are noted during the period 1977-81. During these first formative years, emphasis seemed to be on an attempt to demonstrate existing capability rather than explore new frontiers. Short-term research was the order of the day, often resulting in evaluation rather than research. We needed to demonstrate that we could use the few existing tools we had much more efficiently before we embarked on new ground. Mechanical harvesting was given a high priority in the Jacksonville District. A complete research/evaluation program was conducted. So much so, that it is improbable that any additional research will be necessary. A basic lesson was learned. Regardless of the impetus, if the research is necessary, one of the objectives should be to never have to do this again. I hope that this will be the case with all of our research—the CO_2 laser and mechanical harvesting in particular.

This period saw the initiation of the first Large-Scale Operations Management Test. These tests were designed to determine the feasibility of using certain research results at an operational scale, and subsequently integrating them into the operational system. The use of the white amur fish at Lake Conway, Florida, was the first of these. During this period, the Jacksonville District demonstrated that the implementation of management techniques, using existing control methods, was well within the capability. By designing and implementing a systematic program of chemical application to the waterhyacinth problem on the St. Johns River, they brought the problem to a maintenance level in 2 short years, savings hundreds of thousands of dollars. Today, the St. Johns River remains under maintenance control. Several significant events took place during this period. I will name only a few.

A manual for the use of insects to control alligatorweed was published. The *Neochetina* weevils and moth were cleared for field release after 7 years of quarantine. The Corps-USDA cooperative program was streamlined such that virtually every major new aquatic herbicide was evaluated at the USDA laboratories. A state-wide program supported by the New Orleans District saw the use of biological agents play a significant role in reducing the population of waterhyacinths from 1.75 million acres* to 450,000 acres in 3-1/2 years. In response to an OCE directive to "make this program nationally visible, without becoming a national issue," a public information program was initiated and conducted.

The Districts became so much more aware of the aquatic plant problem in general, and so much better at assessing the scope of these problems, that the reports reflected an apparent explosion of plants. No doubt the plants did grow, but no doubt we had learned how and where to look for those that were already there. As I mentioned earlier, I was trying to establish a direct relationship between the level of a District's APC budget and the scope of their aquatic plant problems. I learned a lot about what is related, but it wasn't what I had originally set out to develop. In studying the reports to Congress, I did make an interesting correlation, however. And it was this: the most prolific growth of aquatic plants occurs during the short period between the report on how well we did with the small amount of money we had last year, and the subsequent request for the necessary amount of money needed to manage the massive problem we will have next year.

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page xi.

1982-85

Beginning in 1982, the requirement for a formal 5-year research and development plan was dropped. There is, however, sufficient documentation requirement remaining in the Corps today to satisfy the need. And it serves, in a somewhat different form, to require us to look at the continuity of our efforts. A vehicle for playing the devil's advocate to ourselves. The period from 1982 to date has seen an unparalleled expansion of the entire APC Program.

Our involvement with the chemical industry to cooperate without subsidizing has proved to be a very productive association. Considering the increasing antichemical activities of certain environmental groups, and the ever-decreasing availability of labeled aquatic herbicides, we have, together, truly obtained blood from the turnip.

The expansion of the technical breadth of the Program brought an awareness of the potential conflict inherent in such an endeavor. The questions still arise: from which technical area of research will the solutions emerge; will biological methods solve the problems; or, will it come from the chemical or mechanical area or from a combination? The answer is yes and no. If you understand the site-specific nature of aquatic plant control, and you include economics and politics as equal determining factors, then each of the control methods will always have its place in some environment and its time for application.

From a research point of view, each researcher must be biased on behalf of his own technical area. If they aren't, I don't want them on this team. This is not to say they should not support the other technical areas. It serves no useful purpose to attempt to elevate one method of control by pointing out the relative limitations of another. Each approach must stand on its own merit. The fourth facet of philosophy is: "*the research program should not be a proponent of any one type of control method, but only the quality and manner in which we conduct our research.*"

On that score, I am very biased. Over the years we have defended areas of research that proved to be applicable in later years. Some being planned at the present time may well prove to be ideas before their time.

The period beginning with 1982 saw the first true expansion of the research units in any meaningful way. While the number of technical efforts doubled, each one now had an objective that could be tied to an existing operational need. Some obvious; some indirect through other research efforts, but related nonetheless.

This period initiated the shift to concentration on submersed aquatics and away from the emergent plants. It was the initiation of work units that addressed the problem of understanding the ecology of the plants themselves, and why they grow like they do, when they do. It reflected the shifting of attention away from the areas of problem assessment and public information, to the area of technology transfer in a usable form. This period may well prove to be the threshold for one of the most productive periods of the Aquatic Plant Control Research Program.

We have now reached that plateau where research and operations cannot only explain their respective needs, but can truly understand what they have learned—in each other's terms. This is reflected in the last 3 years of our program reviews. The field now can verbalize their needs, and, for the first time in this past decade, have

a significant influence on the future direction of technology development. From my viewpoint we are on the way.

Regardless of how someone thinks it happened, two of the four major aquatic plant problems have been brought to a manageable level during this period: alligatorweed and waterhyacinth. Judge it like you will, but stop for a moment and listen to the comments this week; listen to yourself discuss your work over a social, and reflect on 6 or 8 years ago. Sure, those plants are still with us. If we did our job correctly concerning the environment, they will be with us for a long time to come. But they aren't and haven't been the focal point of our discussions.

One of my favorite definitions of research is "to search again or anew." We have already begun one search again and anew: that of the submersed environment. We need not change our philosophies; we need not rededicate ourselves to the task. That we have already achieved. I believe we have reached that balanced level where we are gaining an understanding of the plants themselves; that will accelerate our efforts to apply our knowledge of management methods.

The capability to rapidly and rationally assess the expected outcome of a planned control operation before the fact is a need we have only begun to address. There is a real danger when we feel "fiscally flush"—that we will lose sight of our unaddressed capability needs and forget to fund "our" research. Ironically, we could be vulnerable to once again concentrate on the complexities of the program structure, and overlook the continuing basic technical needs, as we did in 1976. At this point in the game, the outcome would not be as rewarding.

We have in the past conducted research that didn't warrant defending. In most cases the research was initiated for the wrong reason. In a few, it was initiated on a demand that was misconstrued as an operational need. Research conducted for a properly identified, need-oriented objective should be periodically reevaluated to ensure its continuing focus; it should not be continually rechallenged to justify its existence. The formally identified need is either still there until the need is satisfied by results, or it was never there.

As stated in the documentation in 1977, the responsibility for finding better ways to control problem plants rests with the research program. In the APCRP, there is no place for research conducted for the sake of research. Basic research programs have the luxury of only having to advance the state of the knowledge. In an applied research program such as this one, we have the added requirement to advance the state of the art of applying that knowledge, and solve a problem. This added responsibility can only be met through physical, hands-on implementation of teams consisting of both research and operations. In short—demonstrations in the field. During this last period from 1981 to date, we have developed some new capabilities we need to demonstrate.

I cannot close without sharing a few personal thoughts with you. I have long believed that people involved in aquatic plant control must be dedicated, or they don't remain long.

I have spent 10 years of my career associated with an obviously dedicated group. During this time, we have progressed from a small group of stepchildren to expert leaders in this field. I am proud of my association with each of you and the

opportunities to contribute during these last 10 years. My objective is still the same as it was in 1977—do our job so well that we put ourselves out of business.

To our researchers I say you have no peers in my eyes, and I will continue to work for you in the future. I am looking forward to the next 10 years and the successes that will come. The first day of that decade has already begun—so let's roll up our sleeves again.

IN THE BEGINNING

by
Harold L. Blakey*

"In the beginning" — the first three words of the Holy Bible constitute an encompassing credo of Christian faith for more than 2,000 years. In a unique way they introduce hindsight to aquatic plant control for the purposes of this meeting.

It probably does not greatly concern your daily activities that the Corps of Engineers has been in the business of aquatic weed control for nearly 100 years, by mandate of the Congress in Public Law, enacted near the end of the preceding century, authorizing the Corps to undertake a project for improvement of the navigability of coastal waters.

That situation was ready-made for the inventive genius of the engineer. If you have been to Charlestown Landing, you have seen much of the early history of navigation, including the exact replica of the miniature sailing vessels that ventured across the high seas for commerce. These vessels were confronted by barrier islands, a nearly roadless and broad coastal plain marshland in the South Atlantic and gulf coasts forcing them to go upstream to reach the first highland, through passages frequently choked with solid mats of floating weeds.

We understand that initial efforts were made to clear paths for navigation with a multitude of different saws, rakes, and elevators, culminating in a vessel designated as the "destroyer." Disposal of the vegetation treated soon generated more problems than benefits. Crushers were of little avail. Transport of materials and experimentation with ovens and driers were costly.

Even though the fiber value of aquatic vegetation is low and the nutrient value even lower, I am impelled to wonder—if there were a practicable use for the material the problem would change from overabundance to scarcity.

A look over one's shoulder need not symbolize a fear of nearby danger. A look backward in time may be as useful as forward in your search for excellence in planning to avoid pitfalls along the way, to drain both success and failure of their advantages without becoming mere academic exercise. This is functionally an operational program with research to enable adequate planning.

General Cassidy, when Chief of Engineers, had a novel way of keeping staff briefings objective. Were he here, I would expect him to say "Don't tell me just what you are doing—I trust your competence. You are the best in your field—or you wouldn't be here. Tell me what I need to know: Are we getting the job done, in accordance with our mandate, in the best possible way, and within the boundaries of acceptable cost?"

A look at the remainder of your agenda demonstrates that you are carrying out a program in a fully coordinated and integrated manner that gives great promise of

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fulfilling the foregoing criteria, which we on the sidelines can cheer and be justly proud.

I do not know of another operational engineering, biologically oriented research program in the environmental field that has relatively no geographic boundaries, more diversified involvement of governmental interests, or larger numbers of the highest level of professional staff, and the challenge of more unanswered questions at every turn. It is gratifying to me that the Corps has been able to provide leadership in much of this activity.

It should be understood that there has been "oversight" review of the Aquatic Plant Control Program since the beginning of the first project. Changes in this mechanism have evolved consistent with subsequent expansion of the Program and its legislative and administrative needs.

However, it was not until some 60 years later that "directed research and planning" came into the picture with the advent of the establishment of a new Environmental Department in the Federal Government and a somewhat corollary, separate Environmental Branch in the Planning Division of the Office of the Chief of Engineers.

In the beginning it was indeed fortunate that the Corps could draw upon its extensive experience in related fields to assist the new Department in formulation of manual procedures, and in actual instructions for preparation of Environmental Impact Statements required for new projects having significant impact upon the environment. For a considerable time the Corps reviewed *Environmental Impact* Statements and prepared comments thereon for the Department.

I was a relative newcomer in the program in the 1950s and '60s when the Environmental Branch was established as an offshoot and ultimately a replacement of the Policy Branch in the Planning Division.

I am indeed fortunate to be able to attend your conference, having been retired and out of circulation in the field for more than 15 years. I am here to learn more than to impart any words of wisdom. If I cite any matters of experience that challenge you to think, I shall have accomplished my purpose. Furthermore, I am pleased to join with my friend Julian Raynes, who was engaged in the Aquatic Plant Control Program more recently than I and can tell you more about the evolution of the program in the field.

Most of all, I am just glad to be alive—most of my generation are not. I was never a robust youngster, nor am I as an adult, but I enjoy exceptionally good health, which relates to the genes of my rugged progenitors who settled my home state of Missouri when it was the center of the western frontier of our country.

I am reminded of the record of a team of biologists, doctors, and related scientists exploring the limits of human mortality in the highest and most remote regions of the Andes of South America, where they found a native in regard to whom all available evidence supported the fact that he was indeed 140 years old, although his vital signs and thorough external examinations supported the appearance that he should be equal to a man of 40 years.

If you are willing to accept your own ultimate retirement and to understand the benefits that accrue to your career because finitude is a spur to achievement, then you should read Leon Kass' collection of essays entitled "Toward A More Natural Science Biology and Human Affairs."

In the beginning the Environmental Branch of OCE progressively assembled a small staff of five people with widespread experience derived from Federal, State, and regional programs. Assistance readily available from any of the offices of the Corps and other Federal Departments at the Washington level proved to be adquate for administration and planning purposes. However, the need for greater specialization in staff for planning and coordination of research on special problems led to the formation of a research consultant and advisory group from various universities and established research institutions. This group functioned very well for a few years.

I leave you with only a few of the many questions for which the answers are not clear.

There was a time when mountain ranges discharged nearly sterile waters toward the sea. The view from high elevations was crystal clear. Few people, if any took note of the vast empire of economic development in constant change that would take place within one short lifetime. Population shifts to the west along with territorial expansion continue to the present day. Navigation through the St. Lawrence Seaway to the very end of the Great Lakes has facilitated both development of land-based resources and degradation of water resources. More recently the movement of populations from the north to the south has become dominant.

Throughout these changes, populations have invaded waterfronts everywhere with results of overdevelopment of capital improvements, shortage of vital water resources, and creation of a multiplicity of new pollution problems. Has anyone evaluated the impact of these occurrences upon aquatic weeds?

What about natural biological controls of aquatic weeds? Have we made any progress in that field?

The manatee is probably the only mammal with as voracious an appetite for many species of aquatic weeds; but it offers few advantages as a management tool for the obvious reasons that place it on the list of endangered species.

Lesser species of indigenous fish appear to have little effect upon the development of massed aquatic vegetation. Experimentation with certain species of carp was avoided because of possible conflicts in the fish population that would result in damages exceeding benefits. I wonder what became of the initial interest in the Asiatic white amur?

Our most promising biological control effort was the 5-year collaboration with the Department of Agriculture in discovery and adaptation of the South American flea beetle for control of alligatorweed. Initial survival and spread of plantings were satisfactory, but I am informed that alligatorweed has now regressed to a point where it is no longer treated as a special problem and for reasons that are not clear.

I conclude, therefore, that herbicidal treatment remains our principal, if not only, method of aquatic weed control. As a licensed herbicide applicator myself, I am truly concerned about the questions. Do we know enough about where we are going and what we are doing to the environment in treated areas?

I have enjoyed being with you on this your 20th annual meeting and would enjoy, with equal enthusiasm, attending your 40th Anniversary.

IN THE BEGINNING (CONTINUED)

by
Julian J. Raynes*

There was an article in Time magazine a few weeks ago about a radio personality who has a very popular weekly 2-hr show, Garrison Keillor, who talks about Lake Wobegon on his program "Prairie Home Companion." In an interview he said, "I think in telling a story a person is supposed to be carried away." Part of that process, he admitted, involves "learning to talk until you think of something to say."

I am going to try and talk on the subject of "in the beginning" and maybe in the course of my ramblings I'll think of something to say.

All of you are familiar with the 1899 River and Harbor Act which authorized the Corps to remove aquatic growths, first in Florida and Louisiana, and then in Alabama, Mississippi, and Texas. The name of the O&M project is often referred to as the RAG program.

From old records I learned that Congress first was made aware of the problem in 1895 from a Palatka, Florida, resident who requested aid for navigation on the St. Johns River. Subsequently, during the latter part of 1896 a petition for congressional assistance came from Louisiana residents concerned with navigation on the Tickfaw River. The War Department with its US Engineer Offices was authorized to investigate the problem in Florida and Louisiana. The Engineer Offices in 1896 operated then like the Corps does today, in requiring coordination with outside agencies. One of the first things accomplished was to request the Department of Agriculture to prepare a report on the waterhyacinth. That report, completed in 1897, made interesting reading 60 years later.

As you know, the then newly discovered use of 2,4-D in 1945 was believed to be a major breakthrough in control of aquatic plants.

Resolutions passed by Congress in that same year resulted in the preparation of House Document No. 37 in 1948, which if not required reading, should be.

In 1946, on the north Mississippi reservoirs of the Vicksburg District, we were trying to control the vegetative regrowth in the zone of fluctuation for malaria mosquito control. We experimented with applying 2,4-D from an airplane over willows and buttonball bushes in a valley of the reservoir with high banks on both sides. To achieve the desired application rate, we removed the nozzles from the spray rig leaving one open 1/4-in. pipe for discharging the 2,4-D. We required the pilot to fly about 30 to 40 ft above the ground. This was one of the first applications of liquid 2,4-D in the Corps to control vegetation. We learned a lot from the 20 to 25 gal of 2,4-D Ester which we applied. About 3 weeks after our application, we learned how cotton 10 miles away can be affected. During this period I believe that the New Orleans District used 2,4-D dust applied by airplane with similar results to cotton

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fields. We also found that some yields from cotton acreage appeared to show an increase from the previous years harvest and this led to studies by others that 2,4-D had promise as a means of enhancing the cotton yield.

House Document No. 37 was put together by Mr. Berkely Blackmon, Chief of the Planning Section in the South Atlantic Division Engineering Division. Mr. Blackmon's previous experiences in the Jacksonville District, as well as his grasp of the problems, formed the basis for the aquatic plant control program as it exists today. The words "for control and progressive eradication of the waterhyacinth, alligatorweed and other detrimental aquatic plant growths from the water courses," were well thought out.

For example, Mr. Blackmon's wording "control and progressive eradication" recognized that control of weeds is possible and that eradication of weeds is a progressive achievement, and is not obtained in one fell swoop. Some objected to the use of the word "progressive"; however, it is an appropriate interpretation. The wording "other detrimental aquatic plant growths" permits the Corps virtually to conduct control and progressive eradication on "any" type of aquatic plant. In addition, with his foresight, his recommendation not for just research—but for continued research—permits the Corps to maintain the research for an ultimate solution.

The coordination shown with other Federal agencies would almost comply with present-day Environmental Impact Statements. Consistent with many Corps projects which take time to develop, it took about 8 years from submission of the Division and District reports to adoption by the 85th Congress in 1956.

Subsequently, a meeting was held in Atlanta to discuss initiation of the program and preparation of a Design Memorandum for the project. At that meeting both pro and con discussions were held as to the need for continued research since 2,4-D seemed to have provided the answers to program needs. Fortunately, the need for continued research was recognized. The Corps' efforts in biological control were due primarily to Mr. C. P. Lindner, South Atlantic Division (SAD) Chief of Engineering, who recommended and initiated the funding for the Department of Agriculture's first trip to South America. (Mr. Lindner was also a former Director of the Waterways Experiment Station in Vicksburg during the war years.) I don't have a list of those present at that meeting but I believe that Mr. Blakey was present at that meeting.

A second meeting was held in New Orleans with representatives from the cooperating Federal agencies to initiate the research program by those agencies. Francis Guscio, Chief of Master Planning Branch in SAD, took a leading role in those early affairs of the program.

In passing, I should note that the Lower Mississippi Valley Division (LMVD) was given the lead role of assembling the necessary budgetary data and reports to the Office, Chief of Engineers (OCE). This function was given to LMVD by General F. M. Allbrecht, SAD Division Engineer who outranked the General from LMVD. RHIP (rank has its privileges).

We incurred problems with the program right from the start. Our approved Design Memorandum was prepared based on the seven southeastern states

participating in the program. Initially, only Florida and Louisiana participated in the program. The costs for research were prorated to these eight states in the Design Memorandum subject to the 30-percent cost-sharing requirement. Early in the program, because of funding requirements and bookkeeping problems, we requested that OCE amend the Act to show that all costs for research should be at Federal expense and not subject to cost-sharing. Since difficulties in obtaining the hold-and-save-the-Federal-Government harmless were also experienced, SAD also requested changes in that requirement—but was denied.

During those early days those of you from Florida may remember Capt. Noah J. Tilghman from Palatka who was a most vociferous objector to the program. Capt. Tilghman in his large vessel on the St. Johns River provided strictly high-class fishing excursions for people such as Henry Ford, the Rockefellows, and the Vanderbilts, in which good fishing was promised. Many fishery studies by State and Federal agencies were necessitated as a result of the good captain's objections.

As you know the Expanded Project extended control operations from navigable waters to those tributary areas beyond the limits for navigation. With two cost items—one for the O&M's RAG program and one for the Expanded Project—it was not unusual to see control costs for the main channel charged to the RAG program and the shoreline area charged to the Expanded Project.

Meetings such as this one today were initiated in 1961 wherein those agencies involved in research presented their findings in open discussion to a committee consisting of one member from the three Corps Divisions concerned in the program and one member from the participating agencies, i.e., Department of Agriculture, Department of Interior, and US Public Health Service. Because of the concession made by General Allbrecht, Austin Smith, LMVD, was chairman with J. R. Griffith, his alternate; Gordon Jones, SWD, and Francis Guscio, SAD, were Corps committee members. Dr. F. L. Timmons, Department of Agriculture, Dr. H. P. Nicholson, US Public Health Service, and I can't recall the name of Interior's representative from the Fish and Wildlife Service, were also members. Following those open meetings, the committee would meet and hammer out a proposed research program. I remember the first one I attended. I don't believe SWD was represented. Mr. Guscio took only the committee members into his hotel room, locked the door, and for 2-1/2 to 3 hr had an eyeball-to-eyeball meeting and came out with the items to be considered in the research program. No record was made of this closed session. It was then that it was decided that there would be no duplication of research by the agencies with full cooperation between agencies. The recommended program was then furnished to the Divisions for concurrence and then submitted to OCE.

Some of you may remember the Department of Interior's John Steenis who could run across a floating alligatorweed mat barefooted without sinking, others had to resort to Jesus shoes, and the Department of Agriculture's Bob Blackburn and Lyle Weldon who had more test plots from North Carolina to Texas than Carter had pills.

Funding for the pilot project was always limited and during its tenure never reached the $1.5 million a year that the project called for.

The summary report covering the program, completed in 1963, was furnished to

OCE in 1964. As a result of that report, the present Expanded Project was authorized in 1965.

OCE became more actively engaged in the program after enactment of the present project. At that time the Federal policies on research were in the process of being changed from basic research to directed research and Dr. Ralph Scott was employed by OCE to guide the Corps' research program. Dr. Scott, under Mr. Harold Blakey, in his search for innovative ways for aquatic plant control, led to preliminary work using laser beams for hyacinth control at Redstone Arsenal. Before this effort was completed he left OCE. Dr. Edward Gangstad succeeded him and it was this effort that led to the Waterways Experiment Station's involvement in aquatic plant control. The preliminary tests with lasers at Redstone Aresenal showed promise, and as a result WES contracted to build a portable laser for testing. It was believed that a unit the size of a small desk could be developed which would be portable for field use. Some of you may remember the sizable barge that was finally developed and constructed by WES. This was our white elephant which we prefer to forget. Dr. Gangstad during his tenure in OCE initiated the compilation of research documents and minutes of committee meetings for Corps publication.

I must apologize for rambling, but like I mentioned in the beginning, I would talk until I would think of something to say and I think that time has come. Francis Guscio, who attended all of the committee research conferences until he retired in 1971, would remind all the conferees that the emphasis of the program was directed toward accomplishments of successful field operations leading to the control and progressive eradication of obnoxious plants. In performing research for this program, we should not loose track of the goal—determining the necessary research activities in the future.

TECHNICAL AREA PERSPECTIVES

Biological Control Technology Development In Restrospect—1975-1986

by
Edwin A. Theriot*

PRE - 1975

Biological control technology achieved a major accomplishment prior to 1975. Research funded by the Corps and conducted by the US Department of Agriculture (USDA) had resulted in the introduction of three insect biocontrol agents, *Agasicles hygrophila*, *Amynothrips andersoni*, and *Vogtia malloi*, which were extremely effective against alligatorweed. Alligatorweed was well under control in many areas of the southeastern states and California when the Aquatic Plant Control Research Program (APCRP) was assigned to the US Army Engineer Waterways Experiment Station (WES) in 1975.

By 1975, the emphasis had shifted to waterhyacinth. Two weevils, *Neochetina eichhorniae* and *N. bruchi*, had been released in the United States and the search for other control agents continued.

1975 - THE YEAR OF PATHOGENS ON WATERHYACINTH

Drs. Conway, Freeman, and Charudattan of the University of Florida announced the isolation of *Cercospora rodmanii*, a new species of fungus, which was responsible for the mysterious dieback of waterhyacinth at Rodman Reservoir in 1971 (Figure 1). They were also working with *Acremonium zonatum* as a potential control agent. Both species of fungus were being evaluated in combination with *Neochetina eichhorniae* and *Arzama densa* by WES at Lake Concordia, Louisiana. Cross-contamination became a problem during the study; therefore, the effects of each agent could not be separated. The results, however, were significant and warranted further evaluation.

1976 - THE YEAR OF THE GRASS CARP

A major portion of the APCRP review meetings of 1976 was devoted to the initiation of the Large-Scale Operations Management Test (LSOMT) of the monosex white amur in Lake Conway, Florida (Figure 2). Baseline data were collected on the Lake Conway system that year and a technique was developed by the US Fish and Wildlife Service to produce monosex fish for the study.

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* US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Figure 1. *Cercospora rodmanii* infection on waterhyacinth

Figure 2. Grass carp (white amur) used in the Lake Conway and Panama Canal projects for control of submersed aquatic plants

1977 - THE YEAR OF INSECTS ON WATERHYACINTHS

The Argentine waterhyacinth moth, *Sameodes albiguttalis* (Figure 3), was released in the United States to assist the two *Neochetina* weevil species (Figures 4 and 5) in controlling waterhyacinth. The Louisiana Department of Wildlife and Fisheries released several thousand *Neochetina* weevils. This initiated the LSOMT with Insects and Pathogens, which was funded by the New Orleans District and conducted by WES.

The Panama Canal Commission requested the assistance of WES for the control of waterhyacinth and hydrilla. Copper sulfate was being applied by hand for control of hydrilla. The methods being employed were inefficient and detrimental to the system. The WES initiated a study to bring them up to the state of the art in biological, chemical, and mechanical control techniques.

The monosex grass carp was released into Lake Conway based on a stocking rate model developed by WES.

Figure 3. Waterhyacinth moth (*Sameodes albiguttalis*)

Figure 4. Mottled waterhyacinth weevil (*Neochetina eichhorniae*)

Figure 5. Cheveroned waterhyacinth weevil (*Neochetina bruchi*)

1978 - THE YEAR OF PREVENTION

A LSOMT for the Prevention of Eurasian watermilfoil in the Seattle District was initiated. A thorough survey of the State of Washington was conducted in 1978 to determine the level of infestation which had occurred as a result of floating plant fragments from the upper Okanagan and Columbia Rivers in Canada. The purpose of the study was to demonstrate the ability to prevent the spread of Eurasian watermilfoil using fragment barriers, manual removal techniques, intensive monitoring, and an active public awareness campaign. Due to unforeseen delays in Canada's management program and problems in the development of the fragment barriers, Eurasian watermilfoil became well established in Washington. However, the public awareness campaign and monitoring program has no doubt reduced its spread in the state.

Nearly 300,000 grass carp were transported in a massive air lift from the United States to the Panama Canal for control of hydrilla.

An experimental formulation of *Cercospora rodmanii* was developed by Abbot Laboratories of Chicago, Ill., for control of waterhyacinth.

1979 - THE YEAR OF THE LSOMT

The LSOMT with the monosex grass carp at Lake Conway was well under way, the LSOMTs on prevention and the Panama Canal were in their early stages, and the field demonstration phase of the LSOMT with insects and pathogens for control of waterhyacinth in Louisiana was initiated. We were heavily involved in demonstrating the effectiveness of techniques which were developed for control of waterhyacinth and hydrilla. The purpose of the Louisiana study was to develop and demonstrate an operational capability of the use of selected combinations of insects and pathogens for control of waterhyacinth. The waterhyacinth population in Louisiana had reached 855,000 infested acres that fall (Figure 6). Thousands of *Sameodes* eggs were released on waterhyacinth in Louisiana that year.

Emphasis in the research funded by the APCRP had shifted from waterhyacinth to submersed aquatic plants. Domestic surveys for insects on hydrilla and Eurasian watermilfoil were conducted by the USDA. An extensive list of invertebrates which impact these species was compiled. Two insect species, a *Litodactylous* weevil and *Acentria* moth, were evaluated and found not to be sufficiently host specific for development as biocontrol agents.

1980 - THE YEAR OF PATHOGENS ON SUBMERSED PLANTS

The University of Florida was working with a fungus (*Fusarium roseum*) for control of hydrilla. The fungus was isolated from plants collected in Holland. It showed great promise in greenhouse studies as a control agent. Attempts to gain permission for release from quarantine were later abandoned because the fungus was not adequately host specific.

The University of Massachusetts (UMASS) initiated a study on microbial control of Eurasian watermilfoil. The approach was to isolate microorganisms from the

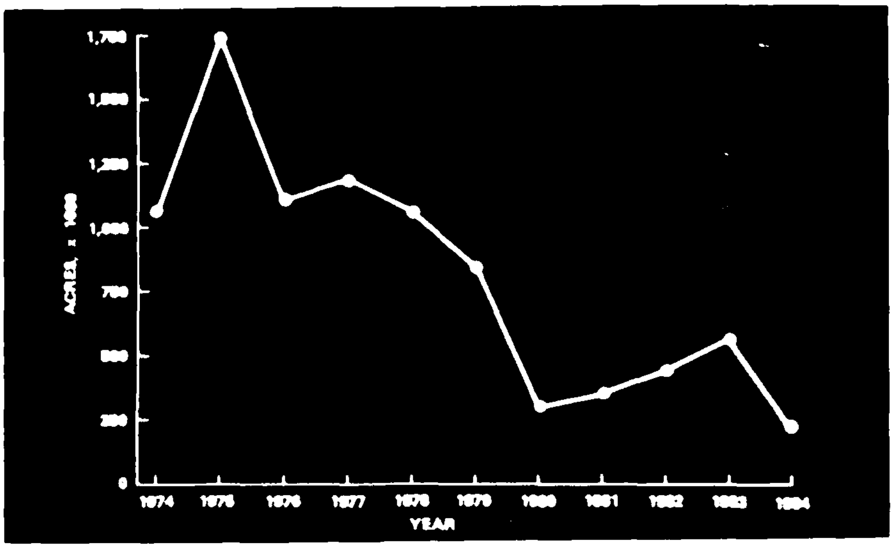

Figure 6. Louisiana waterhyacinth population based on surveys conducted in the fall of each year by the Louisiana Department of Wildlife and Fisheries

microflora of watermilfoil and induce maximum production of lytic enzymes by nutrient conditioning. I'll discuss the progress of this study later.

This was a big year for the LSOMT in Louisiana. A commercially prepared formulation of *Cercospora rodmanii* was aerially applied to 5 acres of waterhyacinth (Figure 7). A technique for mass rearing the native waterhyacinth moth, *Arzama densa*, was developed at the USDA laboratories in Stoneville, Miss. Although *Arzama* proved to be ineffective because of predation, the development of the mass-rearing capabilities is significant. This technique may prove beneficial with insects on hydrilla and/or waterlettuce.

Figure 7. Aerial application of a commercially produced formulation of *Cercospora rodmanii* to waterhyacinth in Louisiana

1981 - THE YEAR OF OVERSEAS SEARCHES FOR INSECTS ON HYDRILLA

A full-scale search for insects on hydrilla in Southeast Asia, Africa, and Australia was initiated by the USDA. Several insects that feed on hydrilla and seem to be host specific were identified. I will discuss more about this later on.

Parapoynx diminutalis was collected from hydrilla in Panama that year and evaluated in US quarantine facilities for host specificity. This species was later found to occur in the United States and, although effective at times, is not suitably host specific for widespread dispersal.

1982 - THE YEAR WES GOES WEST

The Sacramento District and the State of California requested assistance from the APCRP at WES to address the waterhyacinth problem in the Sacramento - San Joaquin Delta. Although the problem was small in comparison to that in the southeast, intensive use of the Delta for recreational purposes and extreme demands placed on the water resources for consumption and irrigation created a situation of urgency. Our objective was to establish the insect biocontrol agents in the Delta and monitor their dispersal. As a result of the State's successful chemical control program, the only large concentrations of waterhyacinth in the Delta occurred in the insect breeding sites. We worked with the State to disperse the insects within the Delta and recommended that they be released upstream in the San Joaquin and Merced Rivers which harbor large infestations of waterhyacinth.

1983 - THE END OF THE LSOMTS

The era of the LSOMT was coming to an end. The fieldwork was completed on the Lake Conway grass carp study, the Louisiana study, the Panama project, and the Washington prevention study and reports were being prepared. The stocking rate model was refined and verified from the Lake Conway study. The fish proved to be an effective tool for control of hydrilla and other submersed species.

The Louisiana study demonstrated the effectiveness of the *Neochetina* weevils for control of waterhyacinth. *Cercospora* in combination with the weevils was also effective. *Sameodes* was not well established in 1983, and therefore, had no significant impact at that time. The waterhyacinth population in Louisiana declined from 1 million acres in the fall of 1974 when the weevils were released to 570,000 acres in the fall of 1983 (Figure 6). We feel that the weevils are responsible for the significant decline as a result of optimal climatic conditions which allowed their rapid buildup.

The Panama project was concluded when the Canal Commission upgraded their chemical and biological programs to the state of the art. Airboats and chemical application equipment were purchased and put into service. Personnel were instructed in the management of insects for control of waterhyacinth.

1984 - THE YEAR OF INSECTS ON HYDRILLA

Permits were obtained for two insects to be brought into US quarantine facilities as a result of the overseas searches initiated in 1981. A *Bagous* weevil from India and a *Hydrellia* fly from Pakistan began being evaluated as hydrilla control agents. We hope to gain permits for the release of the weevil in FY 86.

The first phase of the Galveston District project was completed. *Neochetina* weevils in combination with a native pathogen, *Cercospora piaropi*, was the major factor in the 90-percent reduction of waterhyacinth at the Wallisville Reservoir of the Trinity River Basin. We released *N. bruchi* in the fall of 1980 and *N. eichhorniae* migrated from Louisiana. By 1983 the waterhyacinth had dropped out and parts of the reservoir, which had been choked by the plant for the last decade, were open (Figures 8 and 9).

Figure 8. Wallisville Reservoir on the Trinity River in southeast Texas in 1980 choked with waterhyacinth

Figure 9. Wallisville Reservoir clear of waterhyacinth in 1983

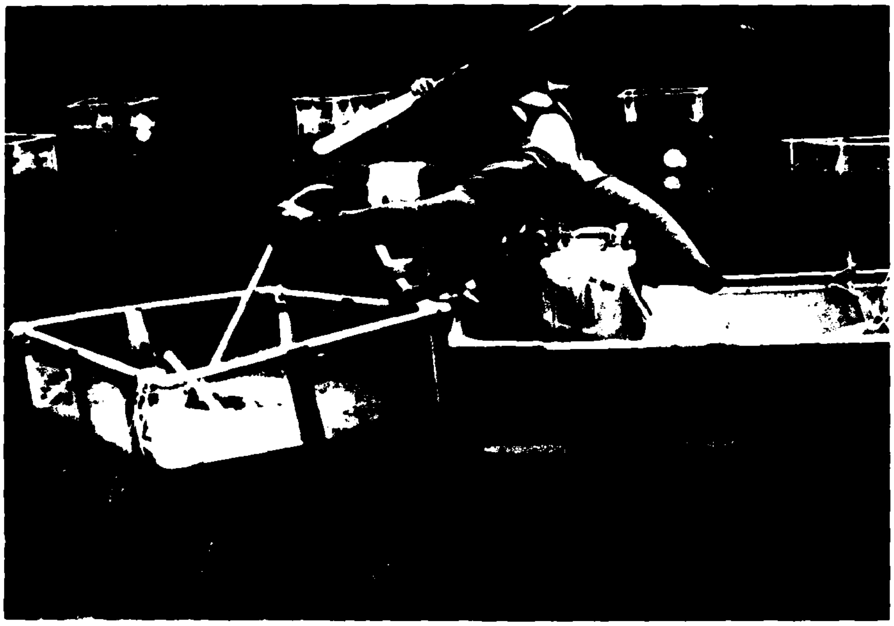

Figure 10. Application of microbial control agents on Eurasian watermilfoil in Stockbridge Lake, Mass.

1985 - THE YEAR OF MICROBES ON EURASIAN WATERMILFOIL

UMASS conducted a small-scale field test with microbial agents for control of Eurasian watermilfoil as a result of the study initiated in 1980. An experimental formulation of a fungus (*Mycoleptodiscus terrestris*) and bacteria (*Erwinia* sp.) was applied to small test plots in Stockbridge Lake, Mass. (Figure 10). A dieback of the plants occurred in 4 weeks. Regrowth of the plants occurred 6 weeks after dieback. The results look promising; however, a more definitive field test will be conducted in FY 86 using a commercially produced formulation applied with state-of-the-art application systems.

A survey for pathogens of Eurasian watermilfoil in the United States was initiated in 1984. The survey was completed in FY 85 and a final report is in preparation. No major diseases were found. However, all microorganisms isolated from disease tissues are being evaluated in the laboratory for virulence on healthy plants.

1986 - THE YEAR OF NEW DIRECTIONS

We will initiate several new research efforts this FY. The first phase of the genetic engineering effort is to identify microorganisms isolated from the microflora of Eurasian watermilfoil and hydrilla that are specific to the plants. Since specificity is the product of several different genes, it is very difficult to

engineer. This is the most critical phase of the study. The remaining phases of the project, including the engineering of the desired trait into the microorganism, are accomplished daily in genetic labs. They require time but pose no major technical problems.

Manipulation of the target plant's microflora is another new research project. The UMASS lytic enzyme study demonstrated that the microflora of aquatic plants contains components that can be manipulated to control its host. We know that opportunistic microorganisms (saprophytic pathogens) exist on the plants, which initiate the decay of the plants during senescence late in the fall. Given optimal conditions for the microbes and/or stress to the plants (temperature, nutrient, mechanical damage, etc.), dieback (premature senescence) will occur early in the growing season. Several mysterious diebacks have been recorded on hydrilla and Eurasian watermilfoil. This study will attempt to identify conditions and components of the microflora required to achieve predictable control of hydrilla and Eurasian watermilfoil.

The use of allelopathic plants (plants that produce compounds which inhibit other plants) and competitive plant species is another new research effort. The USDA at the University of California - Davis and Fort Lauderdale laboratories have been working in this area with *Eleocharis* spp. and have made considerable progress. We will also address revegetation of areas with competitive plant species to prevent the establishment of problem species and to provide beneficial habitat. It may be possible to out-compete submersed species with floating or floating leaf species in some situations.

The use of native aquatic insect species to control hydrilla and Eurasian watermilfoil will also be addressed. Previous research has demonstrated the effectiveness of insects species such as the *Acentria* moth, the *Litodactylis* weevil, and the *Parapoynx* moth in damaging problem submersed aquatic species. All of these insects exist in the United States and severely impact these problem aquatic species from time to time. It is believed that through manipulation (mass rearing, introduction of sterile individuals, etc.) of native aquatic insects, submersed problem plant species can be managed.

We will also initiate studies for insect control of waterlettuce and integrated management of waterhyacinth with insects and herbicides. Two insects (*Neohydronomus* weevil and *Episamea* moth) have been effective in controlling waterlettuce in Australia and Thailand. The Jacksonville District funded the overseas collection of the weevil in Australia and baseline studies in Florida on waterlettuce in FY 85. Waterlettuce is a problem throughout the gulf states; therefore, the APCRP will assist in developing these agents.

These new research efforts represent a shift from the classical biocontrol approach of aquatic plants to an ecosystem approach. The emphasis of the research is to work with the system to manage problem species by manipulating natural factors which affect aquatic plants.

TECHNICAL AREA PERSPECTIVES

Chemical Control Technology Development, A Review

by
Howard E. Westerdahl*

INTRODUCTION

Over the past 8 years many advancements and a few disappointing events occurred that specifically affected current herbicide use in aquatic environments. These will be discussed along with a review of major research areas and future trends in aquatic herbicide development. Also, the future directions of the Chemical Control Technology Department (CCTD) area will be summarized. The major research areas within the CCTD are:

- Controlled-Release Herbicide Delivery Systems.
- Cooperative Herbicide Testing.
- Herbicide/Adjuvant Mixtures for Flowing Water.
- Herbicide Application Techniques for Flowing Water.
- Herbicide Concentration/Exposure Time Relationships.
- Herbicide User Guide.

CONTROLLED-RELEASE HERBICIDE DELIVERY SYSTEMS

Approximately 60 carrier systems have been identified and evaluated over the past 20 years with a variety of aquatic herbicides. To date, only two controlled-release (CR) carrier systems, which have been developed under contract, perform as designed and are amenable to large-scale production: polyGMA polymer and polycaprolactone fiber. The polyGMA polymer has pendent side chains which react with a polar herbicide, e.g. 2,4-D, forming a chemical bond. Release of 2,4-D from the structure is dependent on the rate of hydrogen exchange when the polymer is added to water. The polycaprolactone fiber system physically entraps some herbicides, e.g. fluridone or endothall, in a porous matrix. The release of herbicide in water is governed primarily by diffusional rate processes.

PolyGMA/2,4-D

Under contract during FY 86 with Daychem, Inc., Dayton, Ohio, efforts are currently under way to identify a scale-up procedure that would allow the manufacture of sufficient test quantities for field evaluation during FY 87-88. Following field evaluation, efforts will be made by the developer and the Corps of Engineers (CE) to further develop the polymer and to obtain EPA registration through the private sector.

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Polycaprolactone/fluridone

This formulation was developed under contract with Southern Research Institute, Birmingham, Ala. Over the past several years several fluridone release rates, i.e. 3, 7, 25, and 40 days, have been evaluated under field conditions in the Pend Oreille River, Wash., Winchester wasteway, Wash., Toledo Bend Reservoir, La., and, Lateral 28, South Florida drainage system. Results of these tests showed that this CR formulation is effective and in some instances outperforms conventional formulations. Whereas the CR fluridone fiber outperformed the conventional Black Charm pellet in Lateral 28 and Toledo Bend reservoir, no control was observed with either formulation in the Pend Oreille River and Winchester wasteway.

Additional information on herbicide concentration/exposure time relationships is required before flowing water can be successfully treated with herbicides to control aquatic macrophytes. Current application techniques and herbicide application rates may need to be modified to address flowing water requirements.

COOPERATIVE HERBICIDE TESTING

Over the past 8 years, cooperative herbicide testing with industry and other Government agencies has been an important element in maintaining interest among industries in the aquatic herbicide market. Moreover, it has provided the CE with the opportunity to evaluate herbicide fate and dispersion under field test situations characteristic of CE District aquatic plant management operations at less cost to the Government. Under experimental use permits, the Bureau of Reclamation, Corps of Engineers, and Union Carbide, Inc., collected environmental fate and dispersion data for 2,4-D(DMA) and 2,4-D(BEE). This effort was to support expansion of 2,4-D tolerances and labels to permit use of 2,4-D formulations in controlling Eurasian watermilfoil in water bodies outside the Tennessee Valley Authority (TVA) system. Similar field studies are planned for FY 86-87 in cooperation with Dow Chemical Co. and Uniroyal, Inc., to obtain similar data for Garlon 3A and Casoron 10G, respectively.

Government agencies cooperating with the CE are the Bureau of Reclamation, TVA, and the States of Georgia and Florida. Less intensive field and laboratory testing of fluridone, endothall, glyphosate, and fenatrol have been conducted in cooperation with industry to evaluate efficacy, environmental fate, and/or toxicology of these formulations to target and nontarget aquatic plants in the United States and the Republic of Panama (Gatun Lake).

In all instances, Government cooperation with industry has proved to be cost effective and instrumental in obtaining registration and in broadening the registration of herbicide formulations for aquatic use.

HERBICIDE/ADJUVANT MIXTURES FOR FLOWING WATER

Recognizing the difficulties associated with treating submersed aquatic plants in flowing water, studies were initiated to evaluate the performance of selected adjuvants with representative herbicides. The ability of these mixtures to "hold" the herbicide in the vicinity of the submersed plants at selected flow velocities was

determined. A polar and nonpolar herbicide, 2,4-D(DMA) and dipotassium salt of endothall, respectively, were tested with selected adjuvants at WES and TVA (Table 1) in an attempt to minimize the number of tests which would be required if all registered aquatic herbicides had to undergo similar testing. The most widely used adjuvants for aquatic use include the two inverting oils ASGROW 403 and I'vod and the two polymers Nalquatic and PolyControl. These adjuvants were tested with the aforementioned herbicides in various adjuvant:water ratios at several flow velocities.

Table 1
Herbicide/Adjuvant Mixtures

Asgrow 403 I'vod	Inverting oils	2,4-D(DMA)
Nalquatic Poly Control	Polymers	Endothall

Each test incorporates replicate channels with plant beds approximately 30 cm wide by 50 cm deep by 300 cm long with over 1,000 apical meristems planted and allowed to grow to the water surface prior to testing. Following herbicide application, water samples downstream of the treated plots as well as upstream of the plots are taken at regular intervals using ISCO automatic samplers and analyzed for herbicide residues. Though flow velocities could be increased to more than 50 cm/sec, the plants and chemicals were tested at flow velocities of 1.5 and 3.0 cm/sec. Results of tests using the endothall formulation are incomplete.

At flow velocities greater than 1.5 cm/sec but less than 3.0 cm/sec, results with 2,4-D(DMA) showed that I'vod and PolyControl were two to three times more effective at retaining the herbicide in the vicinity of the plants than other adjuvant mixtures as well as the conventional 2,4-D(BEE) formulation.

Similar studies using other herbicides may be required if the endothall data exhibit different results.

HERBICIDE APPLICATION TECHNIQUES FOR FLOWING WATER

Review of current herbicide application techniques is under way at WES to determine if site-specific characteristics, available equipment, and existing herbicide formulations are suitable for addressing plant control in flowing water. If the existing technology is deemed adequate, better guidance will be provided for these flowing water environments. If new techniques are deemed necessary, e.g., CR herbicides and herbicide/adjuvant mixtures, it may be necessary to encourage development of new formulations.

Combinations of application techniques and improved herbicide formulations are being tested in a hydraulic flume at WES and in a flume facility at TVA's Aquatic Research Laboratory, Brown's Ferry, Ala. As appropriate, field demonstrations of

the most promising techniques will be completed and guidance subsequently provided to CE Districts.

HERBICIDE CONCENTRATION/ EXPOSURE TIME RELATIONSHIPS

Table 2 lists the herbicides tested over the past 2 years and the recommended concentration and exposure time required to achieve control of Eurasian watermilfoil and hydrilla. A diluter system was modified to test these herbicides using four replicates for five test herbicide concentration/exposure times and four reference aquaria. The results of these studies will assist developers in improving herbicide release characteristics from various conventional and CR formulations. Moreover, this information along with data obtained from the herbicide/adjuvant studies will permit decisions to be made concerning the best herbicide and application rate required to control plants under differing flow regimes. Studies with endothall, diquat, and dichlobenil will be completed within the next 2 years.

Table 2
Herbicide Concentration/Exposure Time

	Concentration/Exposure Time	
Herbicide	*Watermilfoil*	*Hydrilla*
2,4-D	2 mg/ℓ/15-30 min	
Fluridone	15 μg ai/ℓ/20-40 days	15 μg ai/ℓ/20-40 days
	30 μg ai/ℓ/12 days	30 μg ai/ℓ/12 days
Dichlobenil	0.3-0.4 mg/ℓ	0.2-0.4 mg/ℓ (retard) continuous
Endothall	To be completed	
Diquat	To be completed	

HERBICIDE USER GUIDE

During FY 86, a draft herbicide user guide will be submitted to District personnel for review and comment. The proposed outline was developed following a working group meeting with specific Districts over the past 3 years:

Chapter	Title (Tentative)
I	Aquatic Plant Identification Guide
II	Herbicide Selection
III	Adjuvant Selection
IV	Selection and Calibration of Equipment
V	Factors for Consideration Prior to Treatment
VI	Factors for Consideration After Treatment
VII	Summary of Federal Regulations

This guide will provide individuals responsible for aquatic plant control with information enabling them to gain sufficient knowledge to develop a control

program with minimal assistance from the CE Aquatic Plant Operations Support Center and WES.

FUTURE TRENDS AND DIRECTIONS

The past 20 years has been a period in which the public has become increasingly aware and sensitive to pesticide use in general. As a result, regulatory agencies have placed more and more preregistration testing requirements on new pesticides produced by industry as well as requiring already registered compounds to complete additional tests as deemed appropriate. This is done to ensure the safety of the environment and the public. Consequently, the minor use markets, including the aquatic market, demand higher product development costs and subsequently longer periods of evaluation. Industry has little, if any, incentive for developing new products for this use or even expanding the use of an already registered product.

The end user in the aquatic market must develop methods to apply existing formulations more effectively, realizing that probably very few new herbicides will be approved over the next 20 years. WES, through the APCRP, will continue to evaluate the potential for modifying existing formulations and tolerances in cooperation with industry in an attempt to improve and expand the uses of existing herbicides. Though the objective for everyone using herbicides should be to reduce their use overall, the key element in being successful will be to develop ways in which the herbicide can be used more effectively in managing aquatic plants.

An additional aspect which may influence the development of new herbicides is the current discussions in Congress concerning extending the patent rights time period to allow more time for the developer to recover the product development costs and return a profit. If this happens, more products would probably be developed for the aquatic market.

Within the APCRP, efforts will continue to improve application concepts and techniques for herbicide use in flowing water. Cooperative field testing of new herbicides will continue to demonstrate our interest in corporate development of new herbicides. There will be a continued effort to better understand herbicide concentration/exposure time relationships, potential effectiveness of herbicide combinations, and the effects of plant phenology and environmental factors on herbicide efficacy. New or improved application techniques will be further evaluated, including controlled-release herbicides, herbicide/adjuvant mixtures, and herbicide encapsulation. Also, alternatives to herbicides will be evaluated, e.g. plant growth regulators.

TECHNICAL AREA PERSPECTIVES

Historical Development of Computer-Aided Procedures for Aquatic Plant Control

by
Thomas D. Hutto*

INTRODUCTION

Although modern computer technology has resulted in the public being more aware of and more willing to accept and use electronic instruments as aids in solving problems in all fields including aquatic plant control research, the need for computer-aided techniques in the APCRP was recognized before 1975, although no significant basic research was devoted to this area until 1984. Although the effort has accelerated substantially since 1984 due primarily to user demand, important work and concepts were accomplished well before 1984.

OBJECTIVE

The objective of this paper is to describe the historical development of computer-aided techniques by WES since becoming the Corps of Engineer laboratory for aquatic plant control research and to briefly describe future work in the computer simulation area. The previous work encompasses the period from 1975-1985.

1975-1985

Before 1975, WES recognized that computer predictive/simulation models could aid in determining the effect of various aquatic control methods on aquatic plant infestations. Computer models are considered most effective in providing estimates of control method effectiveness. So, in about 1975, the first attempt at implementing such computerized procedures began at WES. The first model was developed because a need arose to, in some way, estimate the number and size of fish needed to control an aquatic plant infestation, namely hydrilla. The obvious answer was a mathematical model, preferably a simple one that would run on a small calculator.

So, under the direction of Lewis Decell and Warren Grabau, a first generation fish stocking rate model was conceptualized and programmed to run on a HP19C calculator. Although the model was recognized as having limitations, several important observations related to model structure were made. First, with the problem associated with sampling techniques in estimating fish numbers, there was no need for mathematical elegance. Second, the model should be simple enough that the users, few of whom were biological or mathematical scientists, could understand the logic. This first model attempted to depict the factors that determine the growth

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rate of hydrilla and the consumption and growth rate of the white amur as a function of time and to simulate the interaction between the two that resulted in determining the subsequent infestation. While this model was based on limited data, it was a significant step forward in computer-aided procedures.

In 1977, modeling work began in support of mechanical harvesting of aquatic plants. Mr. S. J. Winfrey of the University of Florida developed for WES a computer program (SHAP) to simulate harvesting of aquatic plants, namely hydrilla. This model was developed to predict/evaluate the performance of the Aqua-Trio Mechanical Harvesting System that was being field evaluated in Florida. Based on data collected during that field exercise, Perrier and Gibson modified the model and published a report on it in 1981.* This stochastic model, in general, attempted to simulate the harvesting operation performed by a harvester unit that cut/mowed and collected the plants, a transporter that carried the plants to shore, and a conveyor that offloaded the plant onto dump trucks that transported them to a nearby disposal site. The statistics in the form of harvesting time and operational cost of each harvesting component and total harvesting cost were computed and displayed with the conversational type program. The development of this model was the beginning of mechanical harvesting simulation work.

In 1980, John Neil of Limnos Limited of Canada contracted with WES in a joint effort with Jacksonville District to demonstrate a different type of harvesting equipment configuration developed by Limnos. This equipment system consisted of a cutter or mowing unit, and a harvesting unit that collected the cut plants and deposited them in a high-speed hammermill that chopped the plants into a slurry. This material was then placed into self-propelled barge units that transported the slurry material to a shore disposal site. The barge was equipped with a pump that deposited the plants onto the land site. In conjunction with this test effort, Neil developed for WES a desktop computer model to evaluate the Limnos system and provided for output on the same harvesting statistics as the Winfrey or SHAP model. This model was a simplistic deterministic model instead of stochastic and did an adequate job of evaluating the Limnos harvesting system.

In 1981, WES, acknowledging that although the Winfrey (SHAP) model and Limnos model were important steps in simulation model development, realized a need to develop a model that would evaluate virtually any conventional mechanical harvesting system. Thus the WES HARVEST model was developed using some of the features of the Winfrey and Limnos models while adding realistic considerations that better simulated actual field mechanical harvesting operations. The HARVEST model, for example, accounted for the effect of changing plant density on harvester forward speed on a swath-by-swath basis. While areal distributions of plant densities are not always available, the model was structured to use these distributions in lieu of the commonly available single value representation of an average plant density. A detailed description of the model was presented at the 15th annual meeting in Savannah, Ga., in 1980 and published in the proceedings.

* E. R. Perrier and A. C. Gibson. 1982 (Feb). "Simulation for Harvesting of Aquatic Plants," Technical Report A-82-1, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Additions to and application of the model were presented at the annual meetings in 1981 and 1983 and published in those proceedings. Numerous simulation studies have been conducted using HARVEST.

In 1982-1983, because of inadequacies found in the original Fish Stocking Rate Model as a result of the Lake Conway stocking results from 1977-1981, a need for a better stocking rate model was realized. A better knowledge of the effects on fish growth, the growth of hydrilla, and the interactions of water temperature, season, cropping of the plants by the fish, and other factors resulted in the development of a second generation stocking rate model by Hal Schramm, designated as STOCK. Outputs of the STOCK model were resultant plant infestations, fish weight, and fish consumption over time.

In 1984 to better serve the operational community, microcomputer versions of both HARVEST and STOCK were developed keeping in mind the principle expressed by Decell and Grabau in 1975, that the logic of any model must be simplistic enough to be understood by noncomputer type individuals. Otherwise, acceptance would be difficult to obtain. With this principle foremost, personal computer versions of the models were demonstrated at the 19th annual meeting in Galveston, Tex., in November of 1984 and published in the proceedings. This "hands on" demonstration resulted in showing the utility of these computer-aided tools to estimate effects of aquatic plant control techniques. A supportive response for these models indicated that computer simulation of aquatic plant control techniques fulfilled a long needed requirement for both research and operational problems.

As a result of the Galveston APCRP computer simulation demonstrations, 19 formal requests nationwide were received by WES in 1985 for the HARVEST and STOCK models and requests continue to be received. Another modeling effort was initiated by WES in 1985 to simulate control of waterhyacinths using two species of *Neochetina*. This model, called INSECT, will mathematically describe/simulate the interaction between the growth of waterhyacinth as varying numbers of the weevils through their life cycle feed on these plants. This model, as with the computer models previously described, will provide predicted estimates of the resultant plant control method effectiveness over time. INSECT has been designed for daily prediction of plant growth and insect development.

SUMMARY

Significant progress has been made in the development of computer-aided procedures as it relates to aquatic plant control in the last 10 years. Now that the importance of computer models has been realized, our goal is to provide personal-computer-based models that will be easy to use by operational engineers in the planning of aquatic plant control operations. Requests for the HARVEST and STOCK models this past year are indeed encouraging. Comments both pro and con as related to these models and future models will help develop improved models for simulation of aquatic plant control method effectiveness.

FY 86

Work planned for FY 86 includes:

- Publish HARVEST user manual.
- Publish STOCK user manual.
- Continued transfer of STOCK and HARVEST to new users.
- Modify STOCK and HARVEST models to include consideration of other plant species.
- Continue development and improvement of simulation model for control of waterhyacinth by *Neochetina* (INSECT).
- Initiate work on simulation model for control of waterhyacinth with herbicides.

BEYOND FY 86

Additional models in the biological and chemical control areas will be developed. Our ultimate goal is to complete these models and incorporate them into one integrated control model that will permit users to simulate various control methods simultaneously and receive estimations that will help determine the most environmentally sound solution to an aquatic plant problem prior to implementation of control measures.

TECHNICAL AREA PERSPECTIVES

Ecology of Submersed Macrophytes: A Synopsis

by
John W. Barko*

INTRODUCTION

A variety of abiotic environmental factors interact in affecting the productivity, distribution, and species composition of submersed macrophyte communities. Foremost among these are light, water temperature, nutrients (including inorganic carbon), and sediment composition. Light and temperature are important in determining morphology and distribution (with latitude, season, and depth), thereby influencing productivity and species composition as well. Sediments provide an important source of several nutrients, which are relatively less available in the open water of most aquatic systems. Inorganic carbon is provided primarily from the open water rather than from the sediment. Carbon availability can be a very important factor influencing the productivity of submersed macrophytes. Sediment composition (i.e., texture and organic matter content) markedly affects macrophyte growth, due to influences on nutrition, but possibly due also to inhibitory properties under certain conditions.

Factors highlighted above have been the focus of intensive study during the past 6 years (1979-1985) within the US Army Corps of Engineers' Aquatic Plant Control Research Program (Barko et al. 1980, 1982, 1983; Barko, Hardin, and Matthews 1984; Barko and Smart 1986; Smart and Barko 1984, 1986). The purpose of this article is to provide a synopsis of major findings of these studies, and to indicate the anticipated direction of related future research.

LIGHT AND TEMPERATURE

Light and temperature over broad ranges appear to interact with essentially equal importance in influencing the growth and morphology of submersed freshwater macrophytes.

Differences in the morphological and/or physiological adaptability of macrophytes to various conditions of irradiance partially account for the greater competitive ability of some species compared with others in aquatic systems. In this connection, species capable of concentrating photoreceptive biomass at or near the water surface in low-irradiance environments are able to competitively displace species possessing relatively prostrate growth forms. Among the species examined in this laboratory, both *Elodea canadensis* and *Vallisneria americana* appear to be

* US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

disadvantaged in aquatic systems characterized by low water clarity because of their limited elongation potential. Conversely, *Egeria densa*, *Hydrilla verticillata*, *Myriophyllum spicatum*, and *Potamogeton americanus* possess a significant ability to form a foliar canopy at the water surface.

From these investigations and related literature, it is apparent that a variety of submersed macrophyte species demonstrate increased growth with increasing temperatures up to at least 28°C. By reducing the length of the growing season, low temperatures effectively diminish the capacity of most (but not all) submersed macrophytes. Considering the distribution of submersed macrophytes in North America, lower temperature limits in combination with basic differences in life cycle may account for variations in the latitudinal range of many species.

The potential for aquatic systems to support excessive submersed macrophyte growth generally increases from north to south in the United States because of the respectively increasing favorableness of temperature conditions. Superimposed on this latitudinal gradient, conditions of both high light and high temperature at the water surface provide a maximum-growth environment for species capable of accessing the water surface. For this reason, even in northern localities, macrophyte species that effectively concentrate biomass at the water surface are potentially more productive than other species restricted to lower positions in the water column.

NUTRITION

From research conducted in this laboratory and elsewhere, it is now generally accepted that rooted submersed macrophytes obtain nitrogen, phosphorus, and micronutrients primarily by direct uptake from sediments. The role of sediment as a direct source of these elements for submersed macrophytes is ecologically quite significant since they are normally very low in concentration in available forms in the open water of aquatic systems. Potassium, however, is an example of one nutrient that appears to be supplied to submersed macrophytes primarily from the water. Considering the usual abundance and conservative nature of other major elements in the open water of most aquatic systems, it is unlikely that low concentrations of these directly limit the growth of submersed macrophytes.

Only in recent years has adequate attention been directed toward the importance of inorganic carbon supply in relation to the growth of submersed macrophytes. Significantly, the photosynthetic potential of a variety of submersed freshwater macrophytes appears to far exceed photosynthesis determined at ambient levels of available carbon in water. Recent studies in this laboratory have demonstrated significant increases in the growth of both *Myriophyllum spicatum* and *Hydrilla verticillata* under conditions of experimentally increased carbon supply. Thus, considering the frequently high availability of nutrients other than carbon to submersed macrophytes, inorganic carbon supply potentially limits macrophyte productivity in freshwater systems.

Losses of nutrients from submersed macrophytes potentially occur through excretion, senescence (leaching), and microbial decomposition (decay). However, nutrient losses from submersed macrophytes appear to be predominantly connected

with senescence and decay. These losses can be quite large, particularly in eutrophic systems due to excessive biomass turnover. Fundamental variations in the abilities of different macrophyte species to retain nutrients may bear on both floristic changes and on differences in macrophyte species composition among aquatic systems.

SEDIMENT COMPOSITION

Sediment composition has a pronounced influence on the growth of submersed macrophytes. In general, growth is relatively poor on both highly organic sediments and on sands compared with that on fine-textured inorganic sediments. Poor growth on sands is related to high sediment density, and on organic sediments to low sediment density. High concentrations of organic matter in sediments negatively affect the growth of submersed macrophytes, by reducing sediment density and the associated availability of essential nutrients (notably, N, P, and Fe). These elements are likewise low in available concentrations in sandy sediments. Thus, mechanisms of growth regulation on sand and organic sediments are similar: both involve nutrition.

In addition to nutritional explanations for macrophyte growth limitation on organic sediments, it is possible that inhibitory factors may also be involved. Experiments in this laboratory have demonstrated that organic matter added to sediments can substantially inhibit the growth of a variety of species. Inhibitory properties of sediment organic matter appear to be associated either directly or indirectly with high concentrations of soluble organic compounds imparted to the sediment interstitial water. Sediments amended by additions of refractory organic matter possess macrophyte growth-inhibiting properties for a longer period than those receiving additions of labile organic matter. Thus, the extent of macrophyte growth inhibition is determined by the type as well as the amount of organic matter incorporated into sediment.

Sedimentation of inorganic materials provides a nutritionally favorable environment for the growth of submersed macrophytes. Inorganic sedimentation is frequently accelerated by human activities in the watershed. For reasons that remain unclear, such systems are most susceptible to the invasion and subsequent explosive growth of introduced macrophyte species. Once such an invasion has been initiated, the strengths and weaknesses of the native vegetation relative to those of the invading species ultimately control the direction of plant succession. In view of these findings, it appears that watershed disturbances, direct mechanical disturbances of bottom sediments, or autogenic processes affecting the inorganic/organic composition of sediments may contribute fundamentally to vegetational changes in aquatic systems.

FUTURE RESEARCH

Knowledge of the independent effects of light, temperature, nutrition, and sediment composition on the growth of submersed macrophytes has increased substantially during the past several years due to research efforts conducted in this

laboratory and elsewhere. It is becoming increasingly necessary, however, to examine the relative importance of these factors in an interactive setting since the influence of any one or several factors in nature probably varies over the range of others. Along these lines, laboratory studies will continue, but these will be augmented by studies conducted in natural water bodies as well.

Investigations of the influence of nutritional factors on macrophyte growth will continue, with increasing emphasis on mechanisms regulating inorganic carbon availability in water, and nitrogen, phosphorus, and iron availability in sediments. These studies will provide better information on environmental conditions conducive to the proliferation of weedy species, and are ultimately anticipated to provide guidance for plant management involving manipulations of the environment.

Whereas a good deal of information is presently available on the influence of the environment on macrophyte growth, relatively little information is available on the influence of macrophyte growth on environment. In an attempt to bridge this gap, studies will be conducted to examine the influence of aquatic vegetation on water and sediment chemistry, in relation to the abundance and distribution of associated invertebrate organisms and fish. These studies are necessary to provide better guidelines for the management of aquatic vegetation, considering beneficial as well as detrimental effects. It is anticipated that the theme of aquatic plant "control" will continue to evolve into one of aquatic plant "management" as advances are made in understanding the ecology of aquatic macrophyte communities.

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TECHNICAL AREA PERSPECTIVES

Historical Development of Mechanical Harvesting Equipment/Procedures

by
Katherine S. Long*

INTRODUCTION

When this group met 10 years ago, the technology of removing noxious water plants with mechanical equipment/devices was in its infancy. Both the machines themselves and the experience of using them optimally were undergoing early development. In the preceding years, the aquatic plant problem coupled with an increased public awareness of possible deleterious effects of chemical pesticides has revived interest in developing mechanical deveices to remove noxious aquatic plants from the Nation's waterways. Contracts have been let to manufacturers of agricultural machinery to develop and to test implements capable of harvesting aquatic plants in a cost-effective way with minimal damage to the surrounding environment.

Along with the ever-increasing task of aquatic plant control came development of an improved capability for analyzing activities through the rigor of operations research. Thus it became possible to examine the feasibility of a machine design without ever building the machine. With the development of computer-aided procedures, many machines and harvesting strategies could be evaluated with little cost compared with former methods.

People for countless years have used their hands and small tools to control the growth and spread of undesired water plants. Irrigation and other forms of water manipulation undoubtedly caused some of the water weed problems. Weeds of all types often respond to a disturbance of the natural surrounding environment by invasion. Early Corps records report waterhyacinth problems in the bayous, lakes, and canals of Louisiana many years before the waterhyacinth is generally thought to have been introduced to this continent.

With the advent of more maneuverable motorized platforms and with the introduction and widespread use of synthetic herbicides, the aquatic plant problems were once nearly reduced to one of routine maintenance. The successful environmental movement reached high visibility in the 60s, motivating pesticide users to be more circumspect about applying chemicals. Mechanical control means were then re-examined to augment, if not to replace, chemical control, such that five different machine models were readily available in 1983. Since that time few design innovations have appeared on the market (Figure 1).

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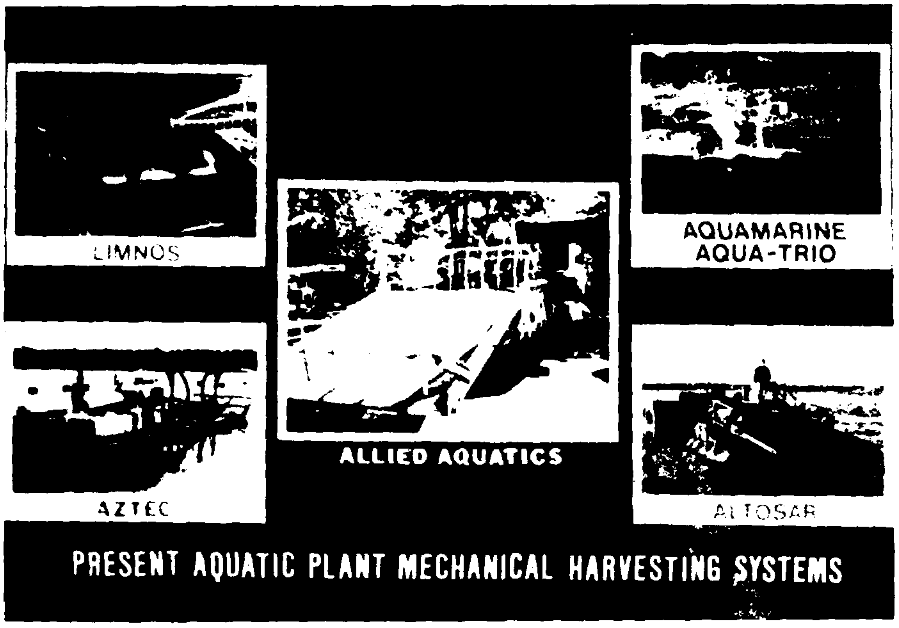

Figure 1. Five mechanical harvesting systems available in 1983

GENERAL FEATURES OF MECHANICAL HARVESTING EQUIPMENT

The machinery normally referred to as a "mechanical harvester" usually has a certain set of component parts:

a. **Cutter or mower.** The cutter or mower is used to remove attached submersed plants a certain depth from the water surface. This unit is usually part of the harvester system.

b. **Conveyor.** This unit is used to convey the harvested plants from a harvester or transporter to a truck at the shore, or to a processor to be further mechanically treated, or to a vessel to transport the harvested plants to a disposal site.

c. **Harvester.** This system is composed usually of a cutter, sloping conveyor, processor/compactor, and holding bay. Most systems do not have processors/compactors.

d. **Transporter.** The main harvester can also be used as a transporter or another vessel can be used to take harvested plants to a remote land disposal site.

WES RESEARCH PROGRAM IN MECHANICAL CONTROL TECHNOLOGY

The WES initiated research in 1975 on mechanical control equipment technology with the first steps devoted to identifying and evaluating existing equipment for controlling aquatic plants. Equipment for controlling both floating and submersed plants was considered. The plants generally considered most noxious at the time

were waterhyacinth, Eurasian watermilfoil, and hydrilla. A technique and checklist were devised to evaluate each of the mechanical harvesting systems in a semiquantitative manner.

Smith* evaluated several handling and manipulating techniques as part of the harvesting process. Methods evaluated included exploiting natural forces (currents) to aid in transporting harvested submersed plants or floating plants to a desired pick-up point. Smith concluded that new equipment must be designed and built if this technique was to be considered an effective plant movement technique.

The characteristics of towing of plant material were likewise examined. Smith concluded that equipment available at that time was inadequate and expensive to operate. Pushing of the plant material (in the water) likewise accomplished movement of insufficient speed to be cost-effective. Moreover, all the methods for moving plant material in the water available at the time proved to be inadequate.

The next step in the research was to develop a computer simulation model of the major mechanical harvesting processes. This computer simulation model (HARVEST) was then used to predict harvester performance for several systems to see how well the model mimicked actual field operations. Adjustments to the model were then made and the model is now well accepted and used for evaluation of mechanical control options. (See paper by Hutto in these proceedings.)

The next step was to use experience and the simulation model to design the "ideal" harvester for a particular job. It was recognized fairly early that floating and submersed rooted plants presented two entirely different mechanical harvesting problems.

At the request of the Jacksonville District, specifications were developed by WES and a request-for-proposal (RFP) was advertised to design and build a mechanical harvesting system(s); one design was for harvesting floating plants and another for harvesting submersed plants. The two sets of equipment would (a) cut, harvest, and convey rooted, submersed plants, or (b) gather, process, and convey floating plants. There was no acceptable design submitted for the floating plant harvester; however, Limnos Ltd., Toronto, Canada, submitted an accceptable design for harvesting submersed plants. This design was based on modification of an existing mechanical system to fit the specifications set forth in the RFP. The Limnos machine had three component parts: self-propelled cutter, self-propelled conveyor-processor, and self-propelled transporter-conveyor.

The harvesting system was constructed, delivered, and tested jointly by WES, the Jacksonville District, and the contractor. Smith** reported on the field evaluations of the Limnos system. As a result of the field evaluations, recommendations made to the manufacturer included specifics concerning design of the cutter bar and the rudder, improvements to the hammermill, and redesign of the pumping system in

* P. A. Smith. 1980 (Jun). "Mechanical Harvesting of Aquatic Plants, Report 2, Evaluation of Selected Handling Functions of Mechanical Control," US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

** J. L. Smith. 1984 (May). "Mechanical Harvesting of Aquatic Plants, Report 3, Evaluation of the Limnos System," Technical Report A-78-3, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

the transport barges. The effects of returning mechanically processed plant materials to the water for disposal and a method of reliably determining in-situ plant biomass were also tested/evaluated during the field test program. Based on field results and use of the computer model, recommendations for the redesign of the various components were made to make the Limnos system more effective for harvesting operations.

After the demonstration/evaluation, the Limnos system was transferred to the Jacksonville District for operational use. The system was used extensively over the next 2 years. However, several mechanical problems developed with the system, which caused considerable downtime and which increased the cost of providing mechanical control. The system was then transferred to another agency which used the system for a short time before other problems developed that made it too costly to use.

USE OF MECHANICAL DEVICES

The Corps of Engineers has used mechanical equipment for control of aquatic plants for a long time. The following summary lists equipment and procedures used by the various Districts and organizations for mechanical control operations and evaluations.

Year	*Reporter, District*	*Type of Plants*	*Equipment/Procedure*
1972	Thompson, New Orleans	Waterhyacinth/ alligatorweed	Crusher boats, booms or barricades; self-propelled, heavy duty Roll Crusher destroyer; sawboat destroyer
1974 (term. 1981)	Koerner and Sabol, St. Paul and WES	Submersed aquatics	Cutter boats with stationary harvester (later analyzed operations with WES HARVEST model)
1976	Hook, New York	Waterchestnut	Hand-pulling from boats and canoes Results—slow decline
1977	Rawson, Seattle	Watermilfoil	Mechanical harvester and fiberglass bottom screens
1977	Thompson, New Orleans	Various	Marsh buggy with cutter bar
1977	McGehee, Jacksonville	Various	Cutter, conveyor, transporter
1977	Rawson, Seattle	Eurasian watermilfoil	Dredges, barriers, hand-pulling
1978	Koegel, U. of Wis.	Submersed	(1) Cutter-conveyor (2) Transporter (3) Presses
1978	Thompson, New Orleans	Floating aquatics	(1) Crusher (2) Conveyor (3) Boom crane (4) "Cookie Cutter" (5) Rake (6) Suction dredge
1979	Kight, Mobile	Various	1-1/2-yd drag bucket, "Cookie Cutter"
1979	Joyce & McGehee, Jacksonville	19 different species	Mechanical and environment manipulation
1979	Hook & Maraldo, New York	Floating and submersed	Mechanical harvester and hand-pulling

(Continued)

Year	Reporter, District	Type of Plants	Equipment/Procedure
1980	Hite, Memphis	Floating and submersed	Mechanical proposed, but not practiced because of obstructions
1980	Paoeglia, Portland	Eurasian watermilfoil	Harvesting
1982	Joyce, Jacksonville	Waterhyacinth, waterlettuce, hydrilla, watermilfoil	Various
1982(?)	Almer, Los Angeles	Milfoil, coontail smartweed	Harvesting
1982	COL W. M. Smith, Jr., New York	Waterchestnut Eurasian watermilfoil	Mechanical harvester with hand-pulling

As evident from the above list, various types of equipment have been used for mechanical control operations. However, the main problem seemed to be one of not matching the equipment with the aquatic plant material to be harvested, which resulted in less than optimum performance of the equipment in the aquatic environment.

STRENGTHS AND LIMITATIONS OF MECHANICAL SYSTEMS

Some of the strengths and weaknesses of mechanical equipment for mechanical control operations are given below.

Strengths

Strengths are as follows:

a. A large area can be harvested in a fraction of the time of manual methods.

b. Usually, there is a limited persistent deleterious effect on the aquatic environment compared with that of certain chemical control measures

c. Less restriction regarding the subsequent use of the water body exists than with certain other forms of treatment.

Weaknesses

Weaknesses are as follows:

a. Some plants when fragmented by harvesting move downstream or to other portions of the lake to become established. Fragmentation of cut, submersed plants can be expected but is a moot point in totally infested, contained water bodies.

b. The draft of the platform of harvesters restricts operations in shallow areas of a water body.

c. Nutrient levels of the water may be altered significantly because of decaying harvested plant material.

d. Harvested plants removed from the water body must be disposed of properly.

e. Care must be taken to ensure the harvesting is done at an optimal time during the growing season. For example, in plants having significant sexual reproduction, harvesting should be scheduled prior to flowering.

f. Large mechanical systems often require repair and maintenance, causing possible extended downtime.

g. Usually, mechanical harvesters cannot operate in water bodies where there is submersed debris, e.g., stumps, submersed logs, etc.

INTEGRATED CONTROL

Mechanical harvesters of present designs are probably not often the treatment of choice mainly because of the expense to purchase or lease and to operate. The necessary bulky design precludes access to the water's edge in many scenarios, thereby leaving significant numbers of plants with reproductive capacity to populate the water body again. Probably the likely solution to this particular problem is some manner of integrated control. Some combinations follow:

a. Mechanical treatment initially could be used to reduce the amount of plant material to be treated chemically, thereby reducing the amount of chemicals required.

b. Biological control mechanisms could be employed with mechanical means in much the same manner as with chemical control.

FUTURE OF MECHANICAL CONTROL RESEARCH

WES and other agencies have not conducted any new research on mechanical control since 1984. The only work ongoing is in the modeling of mechanical systems using HARVEST (see paper by Hutto in these proceedings.)

The future of mechanical control seems to depend on how it can be used in conjunction with less expensive, longer lasting means of control, resulting in optimum control through the integration of mechanical, chemical, and/or biological methods. Mechanical harvesting should be evaluated by use of the WES HARVEST model before conducting field operations.

TECHNICAL AREA PERSPECTIVES

An Assessment of the Aquatic Plant Management Concept (The Yellow Brick Road)

by
Thomas L. Hart* and Kurt D. Getsinger*

INTRODUCTION

At the request of the Aquatic Plant Control Research Program (APCRP) Technical Monitor, the APCRP conducted a planning effort during FY 85 to evaluate integrated control as a potential control technology. As a result of an initial assessment, it was decided that this planning effort should be expanded to encompass an assessment of the aquatic plant management concept and various components of this concept including integrated control and the ecological role of aquatic vegetation. Results of this planning effort would be prepared as a report to be submitted to the APCRP Manager for use in program development. The following is a synopsis of the planning effort as presented at the Aquatic Plant Control Annual Meeting, 18-21 November 1985, in Atlanta, Georgia.

AQUATIC PLANT MANAGEMENT STRATEGY

Aquatic vegetation is an important component of freshwater systems and at moderate levels can have beneficial biological, physical, and chemical effects. Plants create structural complexity within aquatic habitats by providing refuge and substrate for a variety of organisms as well as comprising an integral part of the food web. The physical presence and physiological processes of aquatic plants influence hydraulic conditions and the physical and chemical properties of the water and sediment in vegetated areas. However, human uses of a water body can be severely impacted through heavy infestations of aquatic plants by limiting commercial and recreational activities (including navigation), obstructing industrial and potable water intake structures, and diminishing aesthetic qualities. In addition, an overabundance of vegetation can change predator-prey relationships, increase sedimentation rates, and cause severe fluctuations in chemical and physical parameters. Although all of these factors are important, the human use of a water body is the major factor that determines the nuisance level of aquatic plants for a given system. When human use is nonexistent or minimal, the amount of aquatic vegetation found in a system is of little consequence from a user's perspective; but, if a water body is in great demand, aquatic vegetation has the potential to cause problems for the user. Once a user decides that a potential or actual aquatic plant problem exists in a water body, one of two scenarios usually occurs. The user accepts the situation and learns to "live" with the problem, or the

* US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

user takes measures to correct the situation by attempting to control the growth of the problem plants. Unfortunately, when the latter approach is taken, the use of politically expedient, short-term, or inappropriate measures for plant control are often implemented and do not address the ecological implications to the water body or its designed use.

Over the years, aquatic biologists and lake managers have recognized the inadequacies of short-term solutions to nuisance levels of aquatic plants and have suggested a move toward the long-term management of problem plants rather than to control or eliminate those plants on an annual or seasonal basis. Although this represents a progressive element in the management of aquatic plants, a framework is needed that provides a logical and systematic approach if long-term solutions to aquatic plant problems are to be realized.

One approach to long-term solutions for aquatic plant problems is through an aquatic plant management strategy which considers the design and use of a water body, environmental conditions, types and amounts of vegetation acceptable in a system, and costs associated with managing the vegetation. This management philosophy is summarized in a definition developed by an interdisciplinary group of scientists from WES, other Federal agencies, universities and the private sector, and District personnel which states:

> Aquatic plant management is the process of determining and using ecologically sound strategies to regulate and monitor the growth, composition, and dispersion of aquatic plans at a desired level for an acceptable cost.

There are several advantages associated with the implementation of an aquatic plant management strategy. First, a strategy of one or more selected tactics (e.g., biological, chemical, and mechanical), applied in the appropriate sequence and optimal time of the growing season, will provide more effective control of problem species. Second, tactics which maximize plant control, prevent the establishment of problem species, or encourage the growth of desirable species, will reduce the need for subsequent treatments of nuisance plants. Finally, a management strategy calls for continuous monitoring of the problem and of results. This allows for an iterative process so that management can be "fine tuned." The traditional "patchwork" approach of trying to control or eliminate undesirable vegetation after it has become a problem gives little consideration to long-term environmental and economic implications.

Elements identified as crucial to the success of a management strategy include the following:

- Information on the types, amounts, and locations of aquatic vegetation (via a monitoring program of the water body).
- Determination of acceptable levels and types of vegetation in the system.
- Phenological information on the target species to establish the optimum time for control.
- Information on types of control methods and combinations of methods available with respect to sequence, frequency, and timing.
- Environmental impacts on the system as a consequence of using or not using various control methods.

- Design of water bodies and lake-use planning.
- Operational constraints.
- Economic considerations.

Today an aquatic plant management strategy exists as a concept. Although Corps Districts have and continue to use a number of elements previously described in developing and implementing their annual control programs, the current decision-making process is often based on past experience, which varies widely among individuals and Districts. If the long-term benefits of a management strategy are to become a reality, a framework that defines and delineates the various elements essential to the management of aquatic vegetation must be developed. Based on an initial assessment, the management framework should provide for:

- Defining management goals.
- Selecting appropriate control/management techniques.
- Identifying and assessing ecological and operational constraints/considerations.
- Implementing procedures.
- Minimizing costs.
- Defining monitoring requirements.
- Documenting results.

ECOLOGICAL ROLE OF AQUATIC VEGETATION

A primary factor in the success of a management strategy is understanding the influence of vegetation on aquatic habitats. As a consequence of Federal environmental legislation, personnel charged with the management of CE Projects must consider beneficial as well as detrimental effects of aquatic vegetation in their development of a project management plan. Certain macrophyte species are considered noxious due to a combination of traits, including excessive growth rate under certain conditions and unfavorable growth form (e.g., those that form dense surface canopies). Other species are considered intuitively to be more valuble; however, there is presently no firm basis for assigning ecological value to any single macrophyte species or combination of species. Moreover, there is a lack of data on the influence of aquatic vegetation on water and sediment chemistry in relation to the abundance and distribution of associated invertebrate organisms and fish.

The following studies are necessary to establish guidelines for the sound management of vegetation in aquatic systems:

- The effects of macrophytes on distribution of invertebrates and fish.
- Physical and chemical effects of macrophytes in aquatic systems.
- Macrophytes as a source of dissolved and particulate organic matter.
- Trophic significance of vegetation in aquatic systems.

Results from these studies will provide the basis for determining the direction of vegetation management in relation to the uses of a water body. For example, when the user understands the role of plants in the aquatic environment, he can determine the most desirable plant species for a particular system and manage that system to reduce the undesirable species in a way that is ecologically sound. Also, users will be

able to identify potential problem species and the areas in a water body most likely to support plant growth, and then develop an appropriate management strategy.

INTEGRATED CONTROL TACTICS

The APCRP at WES consists, in part, of four major research areas: biological control technology development, chemical control technology development, mechanical control technology development, and ecological studies. Historically, teams working in these research areas have focused their efforts on solving aquatic plant problems within the confines of a specific discipline (e.g., biological, chemical, etc.), with minimal overlap into other areas.

In the past, these concentrated, single discipline efforts established the basic direction of aquatic plant control and resulted in the development of control tactics for nuisance aquatic vegetation. With the emergence of the management concept for aquatic vegetation, the time is appropriate to evaluate the knowledge attained from research in the individual disciplines of aquatic plant control and explore the possibilities of integrating these ideas and tactics. The previous development of consistent and predictable control tactics for certain nuisance aquatic species and situations has provided the basis for considering combinations of these tactics to achieve longer control and reduce adverse environmental impacts, while meeting management/control objectives. For the purpose of this discussion, integrated aquatic plant control is defined as:

> A single control tactic used sequentially (e.g., utilization of herbicides at various times of the growing season or at different locations within plant stands) or in combination with one or more tactics (e.g., biocontrol agents with herbicides and physical/mechanical tactics) to regulate the growth, composition, and distribution of aquatic vegetation.

Realizing the importance and implications of a management strategy, the APCRP appointed an interdisciplinary team to develop promising integrated aquatic plant control tactics based on recent advances in each of the APCRP research areas. A working group composed of aquatic plant scientists from WES and other Government agencies, academia, and private enterprise met at WES in June 1985 to identify integrated operational and research control tactics. A total of 46 operational/research tactics grouped by vegetation type, i.e., floating, emergent, or submersed species, were identified. These tactics were reviewed by the group and consolidated, modified, or eliminated, as necessary, with 32 tactics surviving the first review process. All 32 tactics were incorporated into a draft document on aquatic plant management. Based on the need for controlling certain nuisance species in CE Projects, availability of proven tactics, and the ability to produce results with District assistance in a short period (1 to 3 years), 13 of the most promising research tactics were selected by the group and developed in greater detail. A second working group consisting of CE District operational representatives and WES personnel involved in aquatic plant control met at WES in October 1985. This group reviewed the draft document developed by the first working group, further refined the integrated tactics, and prioritized the operational/demonstration control tactics.

Further review and evaluation of the draft document by WES personnel resulted in a revision which included seven operational/demonstration tactics ready for field assessment and seven research tactics which should be addressed under the integrated control development technology area within the APCRP. These integrated control tactics address the major nuisance aquatic species (e.g., waterhyacinth, alligatorweed, Eurasian watermilfoil, and hydrilla). However, operational and research results developed under the integrated control technology development area will have applications to other aquatic plant species.

The seven tactics identified by WES and District personnel as being operational and requiring demonstration and evaluation are listed, in order of District priority, in Table 1. Due to differences in site-specific conditions, specific objectives of the operational/demonstration tactics will be developed on a case-by-case basis. The first four tactics receiving most District support concern submersed aquatic plants, followed by two tactics involving emergent plants, and the last tactic being directed against floating plants. A number of Districts expressed interest in cooperating with WES to demonstrate these integrated control tactics during FY 86. The Districts want these tactics demonstrated; but, most importantly, they want each tactic to be evaluated and a report written summarizing results and providing operational guidance to other Districts.

The seven research tactics which form the basis of an integrated control technology development area within the APCRP are listed in Table 2. Since the basic information needed to conduct an aquatic plant management program is generated from the single discipline APCRP research areas (biological, chemical, mechanical, and ecological), numerous interactions will occur between the integrated control area and the other single discipline areas. This "cross-pollination" of ideas and information will strengthen all of the APCRP research areas and result in a multidimensional strategy for managing aquatic vegetation.

Table 1
Integrated Aquatic Plant Control Operational/Demonstration Tactics

Priority	*Tactic*
1	Herbicide treatment following drawdown (submersed)
2	Sequential applications of herbicide and mechanical control methods (submersed)
3	Herbicide treatment followed by grass carp introduction (submersed)
4	Evaluation of grass carp stocking rates as influenced by mechanical harvesting (submersed)
5	Drawdown followed by herbicide treatment and burning (emergent)
6	Timing of herbicide application in combination with harvesting (emergent)
7	Mechanical harvesting in conjunction with water level management (floating)

Table 2
Integrated Aquatic Plant Control Research Tactics

Priority	*Tactic*
1	Insect biocontrol agents and herbicide tactics for waterhyacinth control
2	Compatible pathogen/herbicide tactics for waterhyacinth control
3	Insect biocontrol agents and herbicide tactics for alligatorweed control
4	Microbial biocontrol agents and herbicide tactics for submersed aquatic plant control
5	Microbial biocontrol agents and mechanical harvesting for submersed aquatic plant control
6	Coordination of control tactics with phenological events of aquatic plants
7	Site selection and functional design of aquatic plant habitats

FINAL REPORT

A final report describing the results of the planning effort for those elements identified as components of aquatic plant management is in preparation. This document will discuss the influence of vegetation on aquatic habitats and summarize the results of two working group meetings, conducted at WES, which identified operational and research integrated control tactics. In addition, the report will propose methods for technology transfer of documented integrated control tactics and management strategies, and will recommend development of management strategies and implementation of integrated control tactics.

CORPS DIVISION/DISTRICT OPERATIONS PERSPECTIVES

Lower Mississippi Valley Division, Vicksburg District

by
Julie B. Marcy*

Good morning. My name is Julie Marcy and I am an Environmental Specialist with the Vicksburg District Corps of Engineers. For those of you unfamiliar with the District, it covers parts of Mississippi, Arkansas, and Louisiana, and is part of the Lower Mississippi Valley Division. We are perhaps fortunate in that we have recreation-related aquatic plant problems on only two of seven major reservoirs in the District, and these are both located in Arkansas. DeGray Lake has experienced an overabundance of Brazilian elodea at one of its swimming areas (approximately 1 acre in size) and about a 5-acre problem at DeGray State Park marina. These problems are considered relatively minor, and have not yet been treated. A more serious problem with elodea exists at several recreation areas at Lake Ouachita, in particular, at swimming areas and marinas. In these areas, dense mats of elodea have formed to create an unsightly, obnoxious mess. Last year, we consulted with knowledgeable aquatic plant scientists and applied granular Aquathol K with a cyclone seeder at a rate of 240 lb/acre over 15 acres as per their recommendations. Our results were extremely disappointing, with less than 5 percent of the plants killed. In fact, our current suspicion is that this treatment stimulated the plant growth. Needless to say, we still have a problem, and are seeking a solution at this meeting.

However, we may have another solution around the corner. The Arkansas Game & Fish Commission has begun stocking triploid grass carp or white amur in Lake Ouachita. Their initial plan called for 15 to 20 fish per acre. This has now been reduced to 3 to 4 fish per acre, with the first few thousand fish already released. Periodic aerial photo flights and vegetation surveys will be conducted over the next several years in a joint effort to determine the success or failure of this effort. So, I hope that in a future meeting, we can report a successful effort to you.

* US Army Engineer District, Vicksburg; Vicksburg, Mississippi.

CORPS DIVISION/DISTRICT OPERATIONS PERSPECTIVES

New England Division

by
Susan E. Brown*

During FY 85, the New England Division (NED) completed several studies under the Aquatic Plant Control Program that provided an overview of the aquatic plant programs of the six New England states, as well as reports that discussed the control of aquatic plants in the Charles River and on Martha's Vineyard.

A survey was conducted on the existing state level aquatic plant programs and aquatic plant problems within the six New England states to determine how intensive the state programs are, points of contact for each program, and current problems or projects that the states are working on. Most of the New England states have active programs and are experiencing problems with nuisance aquatic plant growth. The states indicated a strong interest in the Corps program, and we will be coordinating further with the states to specifically determine the areas in which NED can effectively assist the states in the implementation of their aquatic plant programs.

A report was completed that presented a detailed evaluation of the *Codium fragile* (green staghorn algae) problem at Vineyard Haven Inner Harbor on Martha's Vineyard, Mass. This alga is one factor causing an odor problem in the harbor area. The report defined the source and causes of the problem, discussed short- and long-term perspectives of the problem, and provided recommendations for control of the problem.

The Charles River report provided additional information in the development of a long-range management program for a specific area of the river designated as the Charles River Lakes District, which has been experiencing aquatic plant problems for a number of years. A 1984 report had been prepared for NED that provided information on the causes of the aquatic plant problems. The 1985 report followed up the 1984 report with additional qualitative information on the surrounding watershed and the Lakes District itself to assist in a management program for the area.

Future work anticipated in the Aquatic Plant Control Program includes research into the possible use of grass carp for control of Eurasian watermilfoil in Vermont, further investigations on the distribution densities and control of *C. fragile* in salt ponds and coastal embayments in Rhode Island and Martha's Vineyard, and state-of-the-art recommendations to various states on control of aquatic weeds.

* US Army Engineer Division, New England; Waltham, Massachusetts.

CORPS DIVISION/DISTRICT OPERATIONS PERSPECTIVES

North Atlantic Division, Baltimore District

by
H. Glenn Earhart*

INTRODUCTION

Approximately 10 acres of hydrilla was first identified in the Potomac River at Dyke Marsh in 1982. By 1985, the plant had spread and currently infests approximately 600 acres from Alexandria, Va., and south to Quantico, Va. During 1985, hydrilla continued to be a problem for several marinas, property owners, and recreational boaters on the Potomac River. The main navigation channel and major tributaries in the Potomac River remain open. The shallow-water areas along the shoreline and channel flats from the Woodrow Wilson Bridge to Dogue Creek are covered predominantly by hydrilla and to a lesser extent watermilfoil. Given water quality conditions in the Potomac River and known methods and rates of reproduction, more than 34,000 acres of waterway could become infested by 1995.

PLANNING AND COORDINATION

In 1984, Maryland and Virginia officials requested that the Baltimore District initiate a reconnaissance level study. The study was completed in September 1984, indicating that hydrilla existed in sufficient quantities in 1984 to cause a problem of economic importance, and that future spread of the plant would create additional problems. The report also stated that there was a Federal interest in providing plant control and recommended a detailed study leading to a State Design Memorandum (SDM) which would recommend a control program.

A SDM was initiated in October 1984. The document will outline the problems and potential solutions for control and management of hydrilla in the Potomac River including Maryland, Virginia, and the District of Columbia. The SDM will also recommend a plan of action to be cost shared between the Federal Government and non-Federal sponsors. The draft SDM is scheduled to be released to the public in December 1985. The cost of the SDM is $245,000.

DEMONSTRATION TESTS

A series of demonstration tests were conducted in the Potomac River in 1984 and 1985 to provide site-specific information regarding the costs, effectiveness of control, and impacts of various control techniques. Measures under consideration which have proven effective in controlling hydrilla in other areas of the country

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* US Army Engineer District, Baltimore; Baltimore, Maryland.

include herbidices and mechanical controls (barrier mats, harvesting, and diver-operated dredge). The demonstration testing program was consistent with the desires of Federal and State agencies and special interest groups.

Mechanical Control Methods

Barrier mats. A barrier mat test was conducted at Old Town Yacht Club, Alexandria, Va., during the week of 20 May 1985 to assess the effectiveness of various commercially available barrier mats for controlling hydrilla. Approximately one-half acre of Texel and Dartek was placed in two access lanes and twenty boat slips which were heavily infested with hydrilla. The Texel fabric was impermeable to benthic gases and caused the material to balloon 2 days after installation. Also, hydrilla was found growing through the Texel after 45 days in the water. Hydrilla grew through the slits and seams of Dartek, got caught in boat props, and bunched up—reducing the effective treatment width substantially. As a result, Corps personnel removed the barrier mats from the marina at the request of the marina owner on 2-3 July 1985. Both types of barrier mats are not recommended for shallow boat lanes. The cost of the test including monitoring and documentation was $35,000.

Harvesting. Mechanical harvesting was conducted at five separate sites in Maryland and Virginia from 5-14 October 1984. Approximately 8 acres or 54 tons was harvested. The harvester was able to clear one-quarter acre per hour. Estimates from this test established the cost of harvesting in the Potomac River at approximately $600/acre. While this method of control does cause plant fragmentation, the spread of fragments can be minimized by utilizing quality control techniques.

Diver-operated dredge. This test was conducted during 3-13 June 1985 at Belle Haven Marina in Virginia. The purpose of the test was to evaluate the effectiveness of this control method to remove hydrilla. The test demonstrated that use of the diver dredge is possible in the Potomac River. However, the control technique is very costly ($22,000/acre), slow, and labor-intensive. The data also indicate that hydrilla control was not achieved in areas that experienced high boat traffic even though virtually all the biomass and tubers were removed. These areas were rapidly reinfested by hydrilla fragments drifting in from adjacent areas. The cost of the test was $25,000.

Re-establishment of native vegetation

Replanting of native vegetation including wild celery and red-head grass was conducted at four sites along the Virginia and Maryland shoreline during 3-7 June 1985 at a cost of $15,000. This test will assess the effectiveness of transplanted native plants in halting the spread of hydrilla. Results to date show mixed success of the transplants with two sites showing over a 75-percent survival rate and the remaining significantly diminished. The areas are being periodically monitored during this growing season for survival and hydrilla encroachment and the results documented. The effort is being closely coordinated with the states, US Fish and Wildlife Service, US Geological Survey, Virginia Institute of Marine Science, and the University of Maryland.

Herbicide testing

A carefully designed herbicide field demonstration test using the chemical herbicide Diquat was proposed for spring 1985 and a draft test plan was circulated to all interested parties for their review and comment. Both Maryland and Virginia opposed the experimental use of Diquat in the Potomac River and, with few exceptions, most agencies and groups had strong reservations regarding the testing. Of major concern to the states was the perceived contradiction between the introduction of herbicides and the environmental health of the Chesapeake Bay. Both states, however, expressed strong support for continued Corps involvement and development of a nonchemical control plan in high public use areas such as marinas, swimming beaches, and navigation channels. Based on the view of the states and others, the Diquat testing will not be conducted at this time. However, further consideration will be given to herbicides in developing the long-term management and control plan.

SUMMARY

Mechanical harvesting and Diquat have been found to be the best control alternatives. Both alternatives are similar in cost; the use of the herbicide does result in some concerns—the effectiveness of Diquat in the turbid Potomac River, the lack of non-Federal support for Diquat, and the public's adverse perception of chemical use in the Chesapeake Bay area. Assuming that a cost-sharing agreement is reached with the non-Federal sponsors, hydrilla control operations could begin in the summer of 1986.

CORPS DIVISION/DISTRICT OPERATIONS PERSPECTIVES

North Pacific Division, Seattle District

by
Robert M. Rawson*

The history of Seattle District's involvement with aquatic plant control goes back only about 8 years. Eurasian watermilfoil was introduced into Lake Washington in the Seattle area and Okanogan Lake in British Columbia in the early 1970s. As these populations grew in size and density, they began to severely impact the utilization of those water bodies. Also, the Okanogan population was rapidly spreading downstream.

Faced with these two problem areas, the Washington State Department of Ecology in 1977 requested Seattle District assistance in establishing a program to prevent the spread of milfoil in Washington State. We agreed to cooperate with the Department of Ecology under our Aquatic Plant Control Program authority, but the District had no experience in this field. We turned to the Waterways Experiment Station (WES) for help. WES not only provided technical assistance, they also established a 4-year research program to test the concept of a prevention program.

During our environmental review, we received tremendous support from WES, the Jacksonville District, the Tennessee Valley Authority, and the Ministry of the Environment in British Columbia. With this help, we were able to educate ourselves and establish what I think is a good Cooperative Agreement with the Department of Ecology.

Unfortunately, a lot of the Seattle District perspective concerns the spread of milfoil from British Columbia through the Okanogan system and down the Columbia River. The plant has steadily expanded its range in spite of the efforts of WES, the Department of Ecology, Okanogan County, and the Seattle District. Milfoil first appeared in the US portion of Osoyoos Lake in 1978, reached the Columbia River in 1980, and since that time has progressed through Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids reservoirs, and is now appearing in the Hanford Reach area, which is upstream of McNary Reservoir.

Because of the lack of control technology for flowing waters, we find ourselves in the position, in the Columbia River at least, of only being able to document the downstream progression of milfoil. For this reason, we believe that milfoil research and research involving treatment of submerged macrophytes in flowing water should be top priorities in the Corps' research efforts.

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* US Army Engineer District, Seattle; Seattle, Washington.

We have had a fairly stable program in the Seattle area lakes administered by the Municipality of Metropolitan Seattle (METRO), which involves mechanical harvesting and fiberglass bottom barriers. Up until this year we have maintained the milfoil populations in Osoyoos Lake with annual 2,4-D applications. The Pend Oreille River near the Idaho border also has an ongoing 2,4-D program.

This brings us to our perspective on chemical treatment. Howard Westerdahl has already alluded to some of the problems associated with chemical treatment. In our case, we had very strong public opposition from the start in the Seattle area. For that reason, METRO has adopted a nonchemical treatment program.

In the Okanogan area, there was also opposition, but at a much lower level, and Okanogan County made the decision to go forward with the chemical treatment. This last summer, however, an environmental group called Citizens for Environmental Quality - Okanogan filed for an injunction against the program in the Spokane Federal District Court based on the lack of a Worst Case Analysis for 2,4-D. This action was based on the 9th Circuit Court Decision in 1983 which shut down the Bureau of Land Management's forest spray in Oregon for the same reason.

At the time of the injunction, we were in the final stages of preparing a Worst Case Analysis. We had a draft, but no final report that would be defensible in court. For that reason, the injunction was allowed to stand and no treatment was done in 1985. John Wakeman from the Seattle District's Environmental Resources Section will be speaking after me and will go much deeper into the Worst Case Analysis.

Because of this court action, the increasing problems in obtaining Environmental Protection Agency approval for 2,4-D use, the problems with flowing water, and the continued opposition from some members of the public, I have to agree with Howard Westerdahl that we should attempt to limit chemical usage.

Since I've been involved in the program, our District has experienced a very rapidly changing situation as we progressed from the proposed prevention program to the realization that we couldn't stop milfoil from moving downstream, and finally to the point of realizing we have no good tools to use in flowing water. We are much smarter now, but most of what we have learned is what doesn't work and what research needs we still have. Seattle District will continue to support WES's research effort.

CORPS DIVISION/DISTRICT OPERATIONS PERSPECTIVES

North Pacific Division; Seattle District

Estimation of Human Risk Due to Aquatic Application of the Herbicide 2,4-D, Utilizing Worst Case Conditions

by
John S. Wakeman*

INTRODUCTION

In 1985, a portion of Seattle District's watermilfoil control program was stopped because of a legal injunction, which held that the District did not have a completed worst case analysis of risk to human health due to the application of 2,4-D(DMA) in Lake Osoyoos, Washington State. Seattle District was then accomplishing the analysis, but it was not complete. This paper presents findings of the completed risk analysis.

BACKGROUND

The 1979 programmatic Environmental Impact Statement (EIS) had a health risk analysis for 2,4-D, but did not incorporate a worst case analysis since that requirement began after the EIS was finalized. Worst case analysis is required** by 40 CFR parts 1500-1508, Guidelines for Implementing the National Environmental Policy Act (1979) and by case law in the Ninth Federal Circuit, which comprises the west coast states of Nevada, Idaho, Montana, Alaska, and Hawaii and the Marianas and Guam Protectorates. Worst case assumptions are included in the risk analysis when scientific uncertainty impedes reasoned choice amongst alternatives, and when the acquisition of missing data is exceedingly expensive or beyond current technology. Risk analysis normally incorporates conservative assumptions about health effects of a chemical to provide a safety factor to protect the public; worst case assumptions extend the safety factor further by considering (in the present case) highest imaginable exposures. A mid case and a low case (referring to exposure risk) are also used to increasingly relax the highly conservative assumptions and provide more realistic (less catastrophic) conditions.

Despite the fact that is has been used for about 30 years in weed control, 2,4-D is the subject of substantial scientific uncertainty. USEPA is reviewing the

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** The Council on Environmental Quality has recently changed this guidance (FR 51 No. 80, 15618-15625, 25 April 1986), eliminating worst case analysis. However, the case law in the Ninth Federal Circuit Court of Appeals still holds that the worst case analysis requirement is within the spirit of NEPA.

certification of the herbicide because some of the older toxicity bioassays are questionable when reviewed with today's technological standards; USEPA's decision will not be made until 1987. Meantime, Federal court findings were made against the Bureau of Land Management, based on the lack of a complete worst case analysis for 2,4-D, affecting its Noxious (terrestrial) Weeds Program.

OVERVIEW OF RISK ASSESSMENT

The quantitative assessment of 2,4-D looked at the toxicity and hazards due to the chemical and to its possible contaminants, and at the environmental pathways resulting in exposure of the public and the applicators to the herbicide, and compared these exposures to regulatory tolerances and other applicable standards.

Systemic Toxicity and Carcinogenicity of 2,4-D

According to the International Agency for Research on Cancer, the weight of evidence for carcinogenicity is slight; accordingly, carcinogenesis was not considered quantitatively. Human systemic toxicity of 2,4-D is detected from approximately 30 mg 2,4-D (reagent grade chemical, taken orally) per kilogram body weight per day upwards to 80 mg/kg/day, with the latter being lethal. At around 43-57 mg/kg/day, muscular weakness, nausea, vomiting, diarrhea, and nervous system disorders may occur. USEPA established the oral Acceptable Daily Intake (ADI, or no effect level for daily intake over a lifetime) at about 0.5 percent the lower limit of human detectable health effects to provide a margin of safety. The oral ADI for 2,4-D is 0.126 mg/kg/day. Osoyoos Lake and the Pend Oreille River, sites of past treatments, are not used as human water supplies, and they are posted to avert public contact until the 2,4-D levels drop to below the regulatory tolerance limit for drinking water (0.1 mg/l), which usually occurs within 1 or 2 days after application. Nevertheless, the worst case assumptions consider contact with and drinking the water.

Possible Contaminants of the Formulation of 2,4-D

USEPA has assayed numerous commercial formulations of 2,4-D for potentially carcinogenic contaminants, and found such low levels of contaminants as not to raise concern. The potential carcinogenic contaminants found in various formulations of 2,4-D were chlorinated phenols, dimethyl-N-nitrosamine, and chlorinated dibenzo-dioxins. The highly toxic dioxin isomer, 2,3,7,8 TCDD, has not been detected in any analyzed formulation. The low projected maximum concentrations of the contaminants in the receiving water after the Aquatic Weeds Program application, 22 micrograms of nitrosamines per liter or 15 picograms of dioxins per liter, are within USEPA (1980) water quality guidelines.

Exposure Pathways and Exposed Publics

Herbicide applicators and persons ignoring the posted signs to engage in recreation could be exposed to the 2,4-D. Ingestion of food (waterfowl, fish, and shellfish) and hypothetical drinking of, or contact with, lake or river water are recreationalists' main exposure pathways. Projected 2,4-D concentrations in water and aquatic organisms generally exceed regulatory tolerances soon after application, but decline below tolerances in a few days.

Four risk comparison scenarios were postulated, ranging from normal application without unusual incident to a severe spill of concentrated 2,4-D formulation into the boat or the water, and included worst case (maximum) resulting exposures, mid case, and low case (normal) resulting exposure levels. Total estimated daily exposure of the recreational public in the normal application scenario in the worst case is 0.058 mg/kg/day, 46 percent of the ADI. At the other end of the scale, a major spill of 11 gal of undiluted 2,4-D from the application boat could in the worst case represent a significant health risk to the recreational public should they imbide 2 ℓ of water from the lake. The major spill worst case could result in acute toxicity, but in all other scenarios and cases considered, the public exposure did not exceed the ADI.

The herbicide applicators' most important exposure pathways are dermal absorption and inhalation of vapors. Minor or major spills of either diluted or undiluted 2,4-D may present a significant health risk to applicators. A minor in-boat spill in the worst case was 10.7 times the ADI. The major violation of spill within the boat was 3.2-315 times the ADI in the low, mid, and worst cases considered. Normal application practices showed acceptable risk to the applicators; the worst case results were 12.5 percent of the ADI.

CONCLUSIONS

Cautious aquatic applications of 2,4-D when accomplished in strict compliance with labeling information will have no significant human health risk in the areas considered: the Pend Oreille River and Lake Osoyoos, Washington. However, avoiding accidents and violations on the part of the application personnel is identified as the most important factor in risk management. Such risk management practices have been adopted stringently by the Washington Aquatic Weed Program.

CORPS DIVISION/DISTRICT OPERATIONS PERSPECTIVES

South Atlantic Division, Charleston District

by
John L. Carothers*

The Charleston District has a variety of aquatic plant problems including elodea, hydrilla, waterhyacinth, waterprimrose, watersmartweed, and alligatorweed. Elodea continues to be our worst problem. Hydrilla, which was first discovered growing in Lake Marion in 1982, can now be found with elodea in several thousand acres.

Our largest infestation of aquatic plants is in Lake Marion, a state hydroelectric impoundment of almost 100,000 acres. This lake is one of the two lakes in the Santee Cooper system and is one of the premier fishing lakes in the country. Here, the area of infestation is on the order of 30,000 acres.

During FY 85 we treated 5,500 acres of aquatic plants with herbicides including primarily Diquat, Aquathol-K, and Rodeo. Most of this work was done in Lake Marion. Grass carp were purchased for the first time and stocked in 19 lakes having a total surface area of about 2,500 acres. We would have restocked flea beetles if large populations had not been decimated by cold weather in Florida. All work is accomplished under a long-term contract with the South Carolina Water Resources Commission. The Commission subcontracts the work to other agencies and commercial applicators. Expenditures were as follows:

Purchase of grass carp and fish barriers	$108,000
Application of herbicides	655,000
Aquatic plant surveys by the US Geological Survey	55,000
Program management by the contractor	32,000

The total cost of field work was $850,000 of which the State share was $225,000 and the Federal share was $595,000. The State has borne additional costs that could have been cost shared if funds had been available. The State also sponsored five research projects that are not eligible for cost-sharing. District expenditures for planning and contract administration amounted to $53,000 bringing the total cost of the FY 85 program to $903,000.

* US Army Engineer District, Charleston; Charleston, South Carolina.

CORPS DIVISION/DISTRICT OPERATIONS PERSPECTIVES

South Atlantic Division, Mobile District

by
Michael J. Eubanks*

The past decade has proven to be quite dynamic for aquatic plant control activities within the Mobile District. The program has undergone numerous institutional and technical changes, and many gallons of spray mixture have been sent through the nozzle.

Dealing directly with the Aquatic Plant Control Research Program, the past decade saw the Mobile District's research activities draw to a close with the Waterways Experiment Station now assuming these responsibilities. Significant research efforts, which had been conducted under the auspices of the Mobile District, included herbicide testing and toxicological studies by Auburn University and use of lasers for aquatic plant control (Athens College).

Corps jurisdictional and funding boundaries were also adjusted over the last 10 years in an effort to more efficiently manage the Aquatic Plant Control Program (APCP). The Mobile District was involved in this institutional change from all sides. In the late 1970s, the Florida panhandle portion of the Mobile District was transferred to the Jacksonville District, the Louisiana portion (Pearl River drainage) was transferred to the New Orleans District, the Flint River area in Georgia was transferred to the Savannah District. Since 1980, the entire Pearl River Basin has been transferred to Vicksburg District for all Corps activities. While this reduction in area of responsibility may seem to indicate a diminishing program, the aquatic plant control activities within Alabama and Mississippi have increased significantly. A brief summary of the program documentation over the past 10 years illustrates this fact:

May 1977	Design memorandum for the APCP for coastal Mississippi prepared
May 1978	APCP Contract with Mississippi Marine Resources Council initiated
Oct 1978	Final Environmental Impact Statement for the Mobile District Aquatic Plant Control Program filed with the Council of Environmental Quality (CEQ)
Aug 1979	Removal of Aquatic Growth RAG Program for Coastal Alabama and Mississippi discontinued
Sep 1981	Design Memorandum for APCP - State of Alabama approved
Sep 1981	APCP contract with Alabama Department of Conservation and Natural Resources initiated

* US Army Engineer District, Mobile; Mobile, Alabama.

The APCP in Mississippi was aimed at control of a waterhyacinth infestation in a coastal bayou. Based on a combination of spraying and climatic conditions, the hyacinth problem has disappeared and the cooperative program has since been inactive.

The APCP in Alabama was aimed primarily at management of Eurasian watermilfoil in the Mobile Delta and secondarily at control of hydrilla in Coffeeville Lake. Eurasian watermilfoil was first documented in the Mobile Delta in 1975, and a 1979 survey showed approximately 3,000 acres. The cooperative program has involved treatment of approximately 400 acres annually with 2,4-D to improve boat access and creation of openings for fishermen use. Hydrilla was discovered in 1978 in Coffeeville Lake on the Tombigbee River, and in 1981 had spread to approximately 15 acres. Diligent treatments with endothall have effectively reduced the infestation to its current minimal level consisting of a few scattered sprigs. The cooperative program has also been expanded to include waterhyacinth and alligatorweed. Biological and chemical control methods have been applied to these species in the Mobile Delta area. In addition, the State and Corps have been involved in a public awareness program on aquatic plant identification (particularly hydrilla), aquatic plant values, and management strategies. Included in this program have been presentations to bass clubs and civic organizations, media interviews, and radio and television public service announcements. At the present time, the Corps and State of Alabama are finalizing a Cooperative Agreement for continuation of aquatic plant management activities.

Other major areas of aquatic plant growth in the Mobile District are at Lake Seminole, a 30-year-old reservoir on Apalachicola-Chattahoochee-Flint Waterway, and on the recently completed Tennessee-Tombigbee Waterway (TTW). Lake Seminole will be discussed in a separate presentation by Mr. Joe Kight due to the magnitude of aquatic plant growth.

The TTW, consisting of 10 locks and dams creating approximately 44,000 surface acres of water, was officially opened in June 1985. Construction was initiated in 1972 and, after intensive litigation and political controversy, the first tow traversed the completed 236-mile-long TTW in January 1985. Several of the reservoirs have been completed for a number of years and provide a good idea of things to come concerning aquatic plant growth in the TTW. Generally, following impoundment, the shallow quiescent backwater areas immediately show invasion by native aquatics such as duckweed, coontail, American lotus, chara, southern naiad, waterprimrose, pondweeds, and parrotfeather. Some areas after about 5 years of impoundment show encroachment by exotic species including spiny-leaf naiad (*Najas minor*), alligatorweed, waterhyacinth, and Uruguayan waterprimrose. Currently, the only exotic species present in problematic proportions is spiny-leaf naiad. To date only limited control activities have been implemented in an effort to improve small boat access in Aliceville Lake. Chemical efforts have been utilized on coontail, southern naiad, duckweed, and American lotus, while mechanical removal of the small scattered waterhyacinth infestation has proven successful thus far. A major part of the management strategy on the TTW is monitoring for Eurasian watermilfoil and hydrilla.

A significant aid to surveying and monitoring of aquatic plant growth over the past decade has been the use of aerial imagery, particulary video imagery. This technology has assisted in the rapid survey of large water bodies.

At the close of this decade, we are generally optimistic about the future for aquatic plant management in the Mobile District. The cooperative program with the State of Alabama is active. The formation of the Midsouth Aquatic Plant Management Society, with approximately 100 members, encourages the exchange of information between weed managers across the geographical area encompassing the Mobile District. The labeling of RODEO, hopeful labeling of SONAR, and 24-C labeling for 2,4-D (for use on Eurasian watermilfoil in Alabama) have expanded the arsenal available for combating aquatic weeds within our District. It is hoped that the next decade will sustain our optimism as we move toward effective management of our most significant species—Eurasian watermilfoil, hydrilla, waterhyacinth, giant cutgrass, and alligatorweed.

CORPS DIVISION/DISTRICT OPERATIONS PERSPECTIVES

South Atlantic Division, Mobile District, Lake Seminole

by

Joe Kight*

INTRODUCTION

Back in 1975 we had a little over 600 species of aquatic and/or wetland species. Eurasian watermilfoil was the biggest problem, infesting some 8,000 acres. Giant cutgrass covered about 4,000 acres, and hydrilla was established on 600 acres. Since then, watermilfoil spread—and became a problem—from 8,000 acres to about 12,000 acres. As hydrilla spread, watermilfoil, as a problem, decreased in acreage. We now have about 3,000 acres in which milfoil is a problem. Hydrilla increased its holdings from 600 acres to some 15,000 acres today. Seems, at Seminole at least, milfoil cannot successfully compete with hydrilla.

Giant cutgrass infestation is steadily increasing. We now have about 8,000 acres—up from 4,000 acres in 1975. In addition, we now have well over 900 aquatic and/or wetland species. Two of interest are *Egeria densa* and *Salvinia rotundifolia*. It's going to be interesting to see whether *Egeria* or *Hydrilla* will win out. My money is on *Hydrilla*.

We've tried some things that didn't work at all. We've tried some things that worked a little bit, and some things that worked quite well. SONAR, in slow release pellet form, appears to be one that did.

During 2-30 April 1985, 30 plots totaling 639 acres were treated with 25,000 lb of SONAR 5P slow release pellets. The rate of application was 40 lb/acre on 28 plots, totaling 582 acres, and 30 lb/acre on two plots totaling 57 acres. The 1.5-lb active ingredient rate was due to shallow water.

Results of control varied by plot from a low of 0.5 acre controlled per acre treated to 6.1 acres controlled per acre treated. Overall, we treated 639 acres and got control over 2,250 acres.

Hydrilla and Eurasian watermilfoil were target species.

Plants controlled were:

Eurasian watermilfoil	*Myriophyllum spicatum*
Hydrilla	*Hydrilla verticillata*
Coontail	*Ceratophyllum demersum*
Egeria	*Egeria densa*
Cabomba	*Cabomba* spp.
Alligatorweed	*Alternanthera philoxeroides*
Giant cutgrass	*Zizaniopsis miliacea*

* US Army Engineer District, Mobile; Chattahoochee, Florida.

Chara	*Chara* spp.
Parrotfeather	*Myriophyllum brasiliense*

Plants not controlled were:

Tape grass	*Vallisneria americana*
Pondweed	*Potamogeton illinoensis*
Cattails	*Typha* spp.
Lotus	*Nelumbo lutea*
Panicum	*Panicum* spp.
Pickerelweed	*Pontederia lanceolata*

Costs were reasonable too. Application cost, using a helicopter, was $4.95 per acre. Cost of the herbicide was $442.00 per acre. However, the cost of effective control per acre was $120.03, and the areas are still clean of the plants listed.

Vallisneria and *Potamogeton* are making a rather dramatic comeback in the treated areas.

So far, negative aspects of pelletized SONAR are minimal. There is a slight amount of dust present, and it is not recommended that plots of less than 10 acres be treated. These are really minor considerations in that the dust will wash off, and I don't know of anywhere that we have less than 10 acres of hydrilla. It comes, or rather came, packaged in plastic pails that contain 40 lb of pellets, which is the recommended rate for 1 acre. We could treat 1 acre in 3 min with the airboat.

Glyphosate—RODEO—has been labeled for use in aquatic situations. It is quite effective in controlling giant cutgrass. The old standby, 2,4-DMA, is still used on waterhyacinths. They will get out of hand, and we'll knock them back. Usually about every other year they'll require some attention.

As an aside, I found a small mat of hyacinths in the backwaters of W. F. George Reservoir, about 20 miles south of Columbus, Ga. I have wondered how they got there. I know they can swim upstream, jump fences, and probably even portage a little bit—but these would have had to swim 115 miles upstream and go through two lockages. They probably had a little help.

What do we do now? We keep fighting the problem. We have more acres of infestation, but we also have better herbicides—if the Environmental Protection Agency will see fit to approve SONAR. Given present budgets without additional constraints, I think we can hold our own insofar as preventing aquatic plants from adversely impacting navigation, hydropower production, and the ability of the public to use the reservoir.

CORPS DIVISION/DISTRICT OPERATIONS PERSPECTIVES

South Atlantic Division, Savannah District

by
Mark E. McKevitt*

The Savannah District is responsible for the Aquatic Plant Control Program within the State of Georgia. The original contract with the Georgia Department of Natural Resources was signed in 1965. About 1980, the State began to question the complexity of the contract and the amount of paperwork required when compared with the actual amount of onsite treatment attained. They felt that the requirements of the contract more than offset the benefits that they received from the program. For the last few years, the Aquatic Plant Control Program has essentially been dormant. We are currently negotiating a Cooperative Agreement with the State using a less cumbersome format modeled after the Jacksonville District's agreement. We expect that the agreement will be formalized within the next 2 months.

Aquatic weed problems for the most part are located south of the fall line which generally crosses the State between Columbus and Augusta. Nuisance species include waterhyacinth (*Eichhornia crassipes*), hydrilla (*Hydrilla verticillata*), Eurasian watermilfoil (*Myriophyllum spicatum*), Brazilian elodia (*Egeria densa*), giant cutgrass (*Zizaniopsis miliacea*), alligatorweed (*Alternanthera philoxeroides*), and blue-green algae (*Lyngbya* spp.).

When viewed on a state-wide basis, infestation of nuisance aquatic vegetation in Georgia is not an overwhelming problem. However, limited areas have continuous problems and serious localized problems occur from time to time. The Savannah District feels that it is important to establish an active program for the following reasons:

a. We have serious local outbreaks that are difficult to predict. Without an established program, there is no way to implement timely Federal participation.

b. If left untreated, our localized problems will become much more difficult to contain.

c. Both the growing season for plants and the recreation season for boaters extends throughout most of the year in the southeast.

d. We feel that aquatic vegetation can most effectively be controlled on a regional basis. The Savannah District's program will complement operations which are currently carried out by the Jacksonville, Mobile, and Charleston Districts.

The Savannah District and the Georgia Department of Natural Resources both expect to implement our program during the next plant control season.

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* US Army Engineer District, Savannah; Savannah, Ga.

CORPS DIVISION/DISTRICT OPERATIONS PERSPECTIVES

South Atlantic Division, Wilmington District

by
Charles R. Wilson*

Aquatic Plant Control in North Carolina is governed by the North Carolina Interagency Council on Aquatic Weed Control. This council is composed of representatives from State and Federal resource agencies, conservation groups, private industry, and local universities. The Wilmington District and the North Carolina Department of Natural Resources and Community Development are the lead agencies charged with the coordination and funding of control operations. Treatment species presently under the North Carolina Aquatic Plant Control (APC) program are hydrilla and alligatorweed.

Hydrilla was identified at four new sites in 1985, bringing to 18 the number of known sites in North Carolina. All of these sites have been investigated for inclusion under the North Carolina Aquatic Plant Control Program and seven of the sites have been approved. Lake Gaston on the Roanoke River may qualify for inclusion in the program and is still under investigation.

Three of the approved sites are water supplies and until this year have not been treated due to a reluctance by health agencies within the State and the City of Raleigh to use herbicides in water supply reservoirs. The approval of introduction of triploid grass carp into North Carolina waters by the North Carolina Wildlife Resources Commission in 1985 provided the opportunity for the use of biological hydrilla control in the APC program. As a result, 2,000 grass carp were stocked in Lake Wheeler, a 500-acre water supply reservoir for the City of Raleigh, which has a 100-acre infestation of hydrilla. The potential for biological control at the two other potable water reservoirs is being investigated.

Although approved for treatment, Fred Bond Park Lake did not have excessive hydrilla growth this year and no weed control operations were implemented. This site will be monitored during the growing season next year and treated if necessary.

We have just completed our third year of hydrilla control in William B. Umstead State Park, including application of granular Aquathol to 12 acres of hydrilla in Reedy Creek lake and the drawdown of Sycamore Lake with aerial application of Fenac to 14 acres of hydrilla. No herbicide treatments were made in Big Lake so that any residual control provided by FY 84 SONAR applications could be observed. SONAR provided complete control throughout 1984; however, by the 1985 growing season hydrilla had returned to its pretreatment density.

The range of alligatorweed in North Carolina extends from the northern to the

* US Army Engineer District, Wilmington; Wilmington, North Carolina.

southern state line and from the coast to Piedmont. Over 5,000 acres of alligatorweed have been identified from 29 counties in North Carolina.

Alligatorweed control under the APC program for FY 85 included the application of a RODEO and X-77 mixture to problem areas in the Scuppernong River Basin, in Washington and Tyrrell Counties, and in the Little River Basin in Pasquotank County to remove obstructions to recreational boating. Successful FY 84 alligatorweed control efforts reduced the area which required treatment on the Scuppernong to 5 acres in 1985. Herbicide application was expanded in 1985 to include navigable tributaries to the Scuppernong with an additional 3 acres treated in those areas. Three acres of alligatorweed in the Little River Basin were also treated in this fiscal year.

The District provided support to the North Carolina Department of Agriculture in a project to develop a cold-tolerant flea beetle. The selection program is ongoing with initial releases of selected cold-tolerant stocks made in southern North Carolina in September of this year. These sites will be monitored to determine if overwintering of flea beetles has occurred.

No aquatic plant control is presently being undertaken at any Wilmington District reservoirs; however, several of our reservoirs are in close proximity to infested lakes. Our primary efforts at this time have been toward education of both the general public and the reservoir management staff. Project biologists have been trained to recognize potential problem plants, and all boat ramps have been posted with signs instructing users to clean their boats and trailers prior to launching. Through an effort of the North Carolina Aquatic Weed Council, non-Corps lakes, which have hydrilla, have also been posted with signs alerting users to the potential for the spread of noxious aquatic plants.

Excess waterprimrose growth continues in Falls Reservoir; however, this year's peak growth did not appear to be as bad as the summer of 1984. So far, boat channels remain open, and the weed is not significantly interfering with recreation or project operation; and no treatment is planned at this time. If waterprimrose begins to cause problems, a control program will be developed.

Planning efforts under the APC program during FY 84 included initial studies for the inclusion of elodea as a treatment species and the completion of a reconnaissance study and report for the inclusion of drainage canals as a new alligatorweed treatment area. Studies for the inclusion of elodea are ongoing and are expected to be completed this fiscal year.

The reconnaissance investigation was made in response to a resolution to the North Carolina Aquatic Weed Control Council from Washington and Tyrrell Counties, North Caorlina, requesting that major drainage canals tributary to the Scuppernong River be included in the ongoing cooperative Corps/State alligatorweed project on the Scuppernong. Alligatorweed growth in the canals was found to be excessive and control would provide significant public benefits due to improved drainage and increased crop production in excess of control costs. The reconnaissance report is presently under Division review for approval.

For this FY and in the future, we plan a continuation of the existing control program for hydrilla and alligatorweed with expansion to cover new treatment species and sites as appropriate.

CORPS DIVISION/DISTRICT OPERATIONS PERSPECTIVES

Southwestern Division, Galveston District

by
Joyce Johnson*

Although the Galveston District boundaries are generally from the Texas gulf coast to about 200 miles inland, the District is responsible for the Aquatic Plant Control Program operations in the entire State of Texas. Fort Worth District is responsible for aquatic plant control operations in project areas such as Sam Rayburn Reservoir and Dam B within the boundaries of their District, and Tulsa District manages Pat Mayse Reservoir, which is also in the eastern part of Texas. The control of noxious aquatic plants has been managed by the Galveston District since 1968. A General Design Memorandum and Environmental Statement for the control of alligatorweed and waterhyacinth were published in the early 1970s. Most of the control work in the past has been along the coastal regions within the District boundaries. However, hydrilla has spread throughout the state, particularly in east Texas, and future work will be expanded accordingly (Figure 1).

This past year Supplement No. 1 to the General Design Memorandum was completed and forwarded through Division to the Office of the Chief of Engineers. An Environmental Assessment was also coordinated with the Environmental Protection Agency and interested agencies and individuals. These documents address the inclusion of hydrilla and Eurasian watermilfoil in the Texas program. No adverse comments were received on the assessment. The initiation of the control activities for the new work is anticipated during February 1986.

During the 17-year history of the Aquatic Plant Control Program in Texas, the Galveston District has had four cost-sharing contracts with the State of Texas. The Texas Parks and Wildlife Department plays an active, vital role in the Texas program, performing most of the fieldwork and all of the herbicide spraying. In the past, 2,4-D (dimethylamine salt of 2,4-dichlorophenoxyacetic acid) has been used exclusively in the herbicide program; however, other herbicides will be used during 1986 in the effort to control hydrilla. Alligatorweed is controlled predominately by *Agasicles* flea beetles in Texas at the present time. Populations that dwindled during the late 1970s have been supplemented by releases during the past 4 years by the Waterways Experiment Station (WES) with insects provided by Florida or collected in Louisiana. In addition, WES has introduced other biological agents including *Neochetina bruchi*, *Neochetina eichhorniae*, and *Sameodes albiguttalis* for the control of waterhyacinth and *Vogtia malloi* for alligatorweed control. It is anticipated tht the State of Texas will continue the work started by WES by incorporating the biological agents in the cost-sharing program. Several nursery

* US Army Engineer District, Galveston; Galveston, Texas.

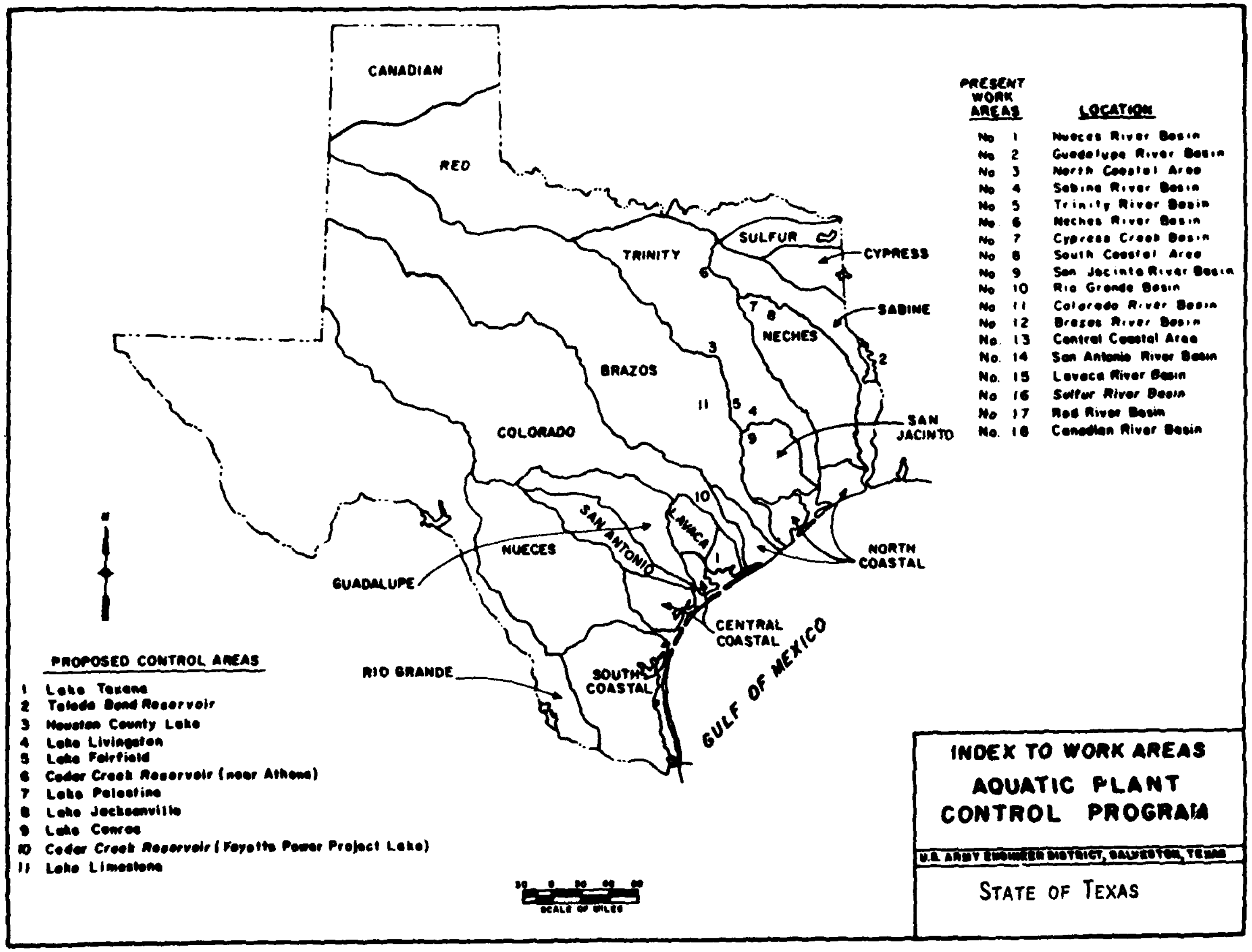

Figure 1. Aquatic plant control in Texas

areas for these species have been established during this WES effort. The acceptance by the Texas Parks and Wildlife Department of a renewed emphasis on biological control of aquatic species has been due, in large part, to the quality of the work done by the WES team, including Ed Theriot, Al Cofrancesco, and Mike Stewart.

During the spring-summer herbicide spray program, the Texas Parks and Wildlife Department had five crews stationed in three areas treating waterhyacinth. There was a marked decrease in the acreages treated during 1985 when seven crews were active in Texas. The cause of the decreased incidence of waterhyacinth during this past season is due to harsh winters in 1984 and 1985 and a severe drought in the south-central portion of Texas. Lake Corpus Christi, where in the past there have been extensive infestations, was practically dry for the past 2 years. Regrowth of waterhyacinth from seeds is occurring late in the season and treatment is continuing through November in Lake Corpus Christi, according to Bob Bounds, the State Coordinator for the Aquatic Plant Control operations.

It is expected that with the inclusion of submerged species, such as hydrilla, the program will be expanded significantly. The proposed control of hydrilla is limited to treatment of boat ramps and access in 11 presently infested lakes in Texas. However, since the herbicide costs involved in treatment of hydrilla are so much greater than costs associated with treatment of waterhyacinth, the program will cost nearly three times more than in the past. It is clear that a less costly, environmentally compatible method of hydrilla control is needed in the Galveston District program.

During 1986, the Galveston District intends to pursue negotiation of a cost-sharing cooperative agreement with the State of Texas in an attempt to simplify the program and reduce the administrative costs associated with negotiating modifications to the existing contract or new contracts each year. Another goal of the program will be to improve the communication between the Galveston District and the Operation Support Center in the Jacksonville District to incorporate their extensive experience in solving the problems encountered in the expanded program to control hydrilla and Eurasian watermilfoil.

CORPS DIVISION/DISTRICT OPERATIONS PERSPECTIVES

Southwestern Division, Tulsa District

by
Loren M. Mason*

RETROSPECTIVE REVIEW

The Tulsa District over the past 10 years has experienced moderate to severe aquatic plant problems on several lake projects and navigable waterways within the District. During that time period, reconnaissance surveys (Figure 1) of aquatic plant infestations have resulted in the identification of 12 major impoundments in the State of Oklahoma, totaling 8,300 acres and one major impoundment in the State of Texas, totaling 500 acres of Eurasian watermilfoil (*Myriophyllum spicatum*). A variety of other aquatic plants including waterprimrose, najas, chara, potomogeton, nelumbo, etc., are present but are considered manageable at present infestation levels.

As a result of the reconnaissance surveys, a State Design Memorandum was coordinated and developed with the State of Oklahoma in 1981 to allow local entities to receive cost-sharing assistance to control nuisance aquatics. At this time no work has been performed under the cooperative program with the State of Oklahoma, although Eurasian watermilfoil continues to slowly expand in many state and local municipal water supply and irrigation reservoirs.

DISTRICT PROGRAMS

The Tulsa District has two projects with infestations of Eurasian watermilfoil: Robert S. Kerr Lock and Dam and Reservoir, Oklahoma; and Pat Mayse Lake, Texas.

With assistance from the Waterways Experiment Station, a problem identification and assessment survey and a management plan were made for the Robert S. Kerr infestation in 1977, and a chemical control program using 21,000 lb of BEE 2,4-D (butoxyethanolester of 2,4-dichlorophenoxy acetic acid) was applied in 1978 in eight areas, totalling 187.5 acres of Eurasian watermilfoil. The treatment program was monitored by the Oklahoma Water Resources Board and was determined to be 100-percent successful with no adverse impacts.

The Eurasian watermilfoil infestation in Robert S. Kerr is considered to be insignificant since there is no indication to date that the plant will return to the previous infestation levels (1,200 acres) experienced in 1976 through 1979 (Figure 2).

* US Army Engineer District, Tulsa; Tulsa, Oklahoma.

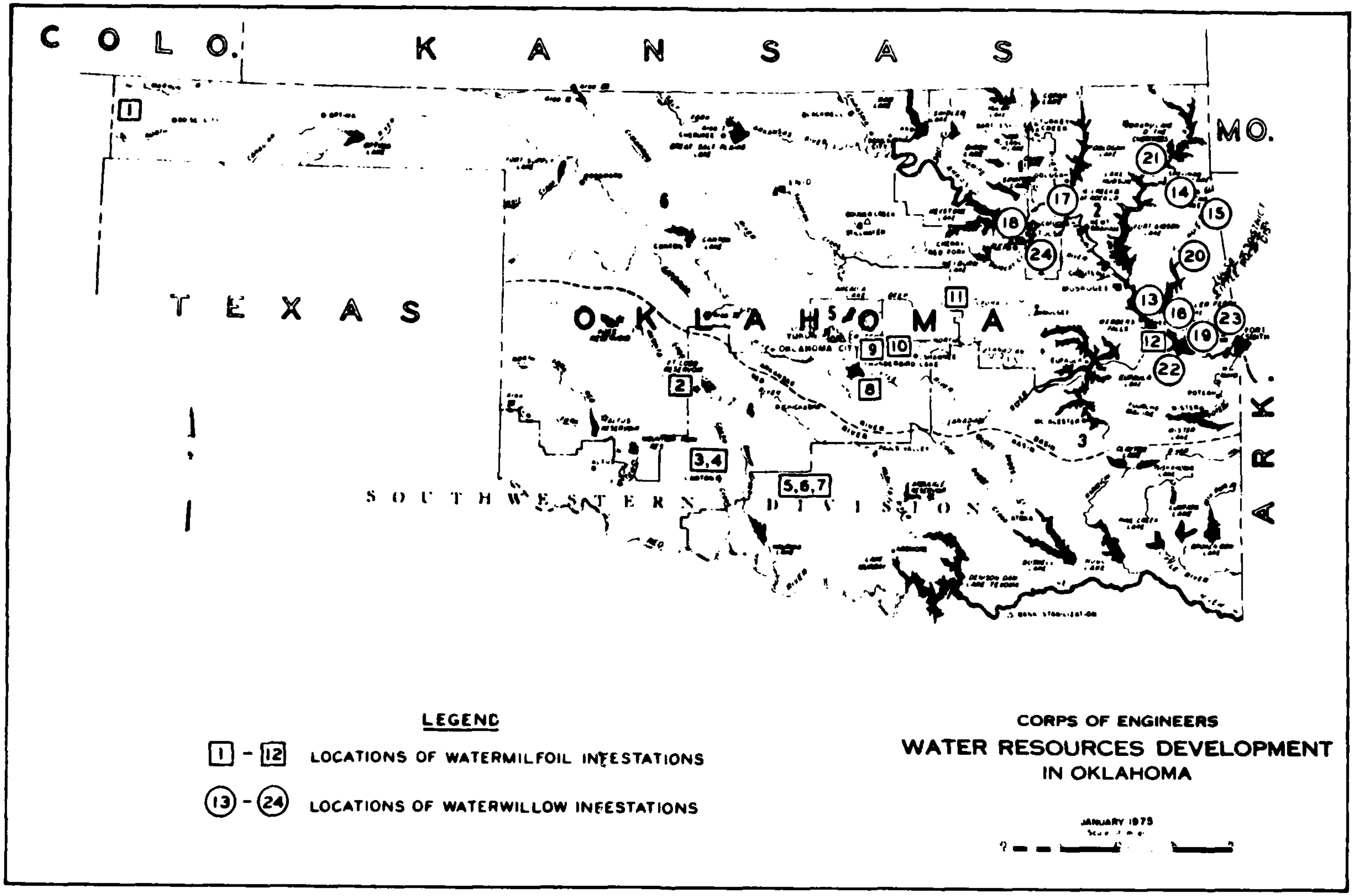

Figure 1. Aquatic weed reconnaissance survey in Oklahoma

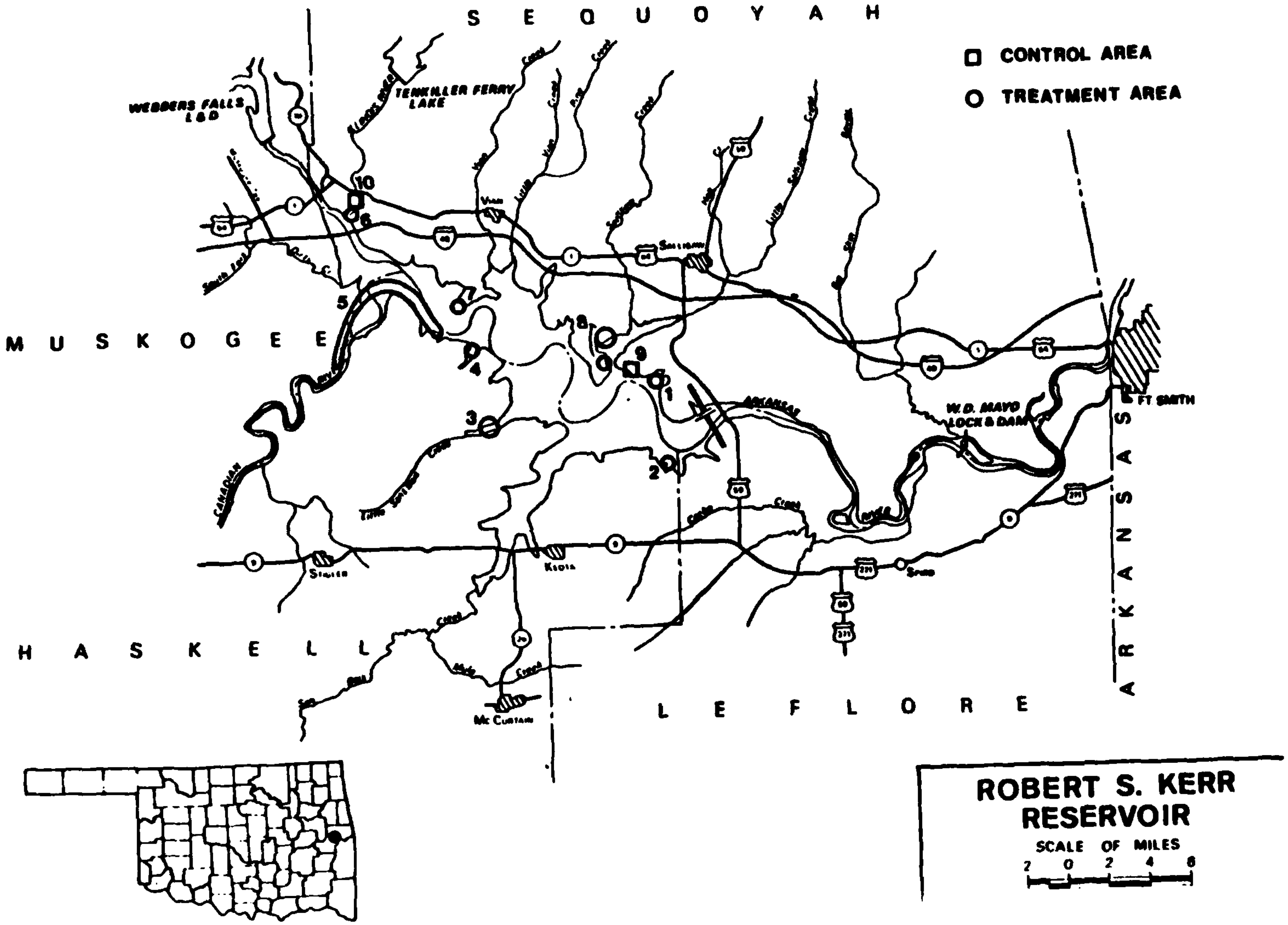

Figure 2. Eurasian watermilfoil monitoring sites. Areas 1-8 were treated with BEE 2,4-D and areas 9 and 10 were controls

The infestation of Pat Mayse Lake, Texas, by Eurasian watermilfoil (1,000 acres) in 1981 through 1983 caused serious safety and utilization problems of the lake. As a result, a chemical treatment program was initiated in 1983 on 93 acres using endothall (granular formulation of dipotassium salt of endothall) for a total application of 23,250 lb. The treatment sites were monitored (Figure 3) and the result of the treatment program was a 100-percent kill with no detectable adverse impacts in the treated or untreated areas. Since the 1983 treatment program, the District's emphasis at Pat Mayse has been placed upon the development of operational tools and criteria that can be utilized to forecast aquatic plant growth and to determine the best type of integrated treatment controls that would produce a satisfactory maintenance program on Pat Mayse Lake.

OPERATIONAL OBJECTIVES

In support of developing operational information for an integrated control program, the 1985 Pat Mayse studies were concentrated on the following tasks:

- Evaluate the waterbug cutter harvester and pushboat system as a tactic for control of aquatic plants (primarily Eurasian watermilfoil) in lieu of and/or in cooperation with chemical control techniques.
- Examine sediment accumulation rates in the lake.
- Continue collection of chemical data on water quality and aquatic plant biomass growth.
- Evaluate the WES Mechanical Harvest Simulation Computer Model for its use and application in the Pat Mayse management control program.

STUDY RESULTS AND CONCLUSIONS

Based upon the comprehensive 1985 field studies and subsequent studies of 1982, 1983, and 1984, the following conclusions can be made regarding the growth and control of aquatic plants in Pat Mayse Lake:

a. One well-timed harvest treatment program will probably be sufficient to control undesirable quantities of watermilfoil for a growing season. About 3.25 hr will be required to cut an acre of watermilfoil and about 5 hr would be required to remove the plant material approximately 100 yd to a takeout point with the pusher boat. The optimum depth of cut is greater than 3 ft and less than 5 ft.

b. A Pat Mayse Lake model has been developed for cost predictions for future harvest operations. The model is implemented on a microcomputer and facilitates cost calculations with changing labor, repair, and material costs.

c. Maximum watermilfoil biomass of 7.3 tons/acre was observed in August 1985, with approximately 580 acres of infestation. If the winter conditions are not severe and the lake water remains clear, some management effort may be required in 2 years.

d. Profuse flowering of Eurasian watermilfoil was observed during September 1985. Apparently, sexual reproduction is important in Pat Mayse Lake and may lead to adaptations to overcome limitations to growth and dispersion.

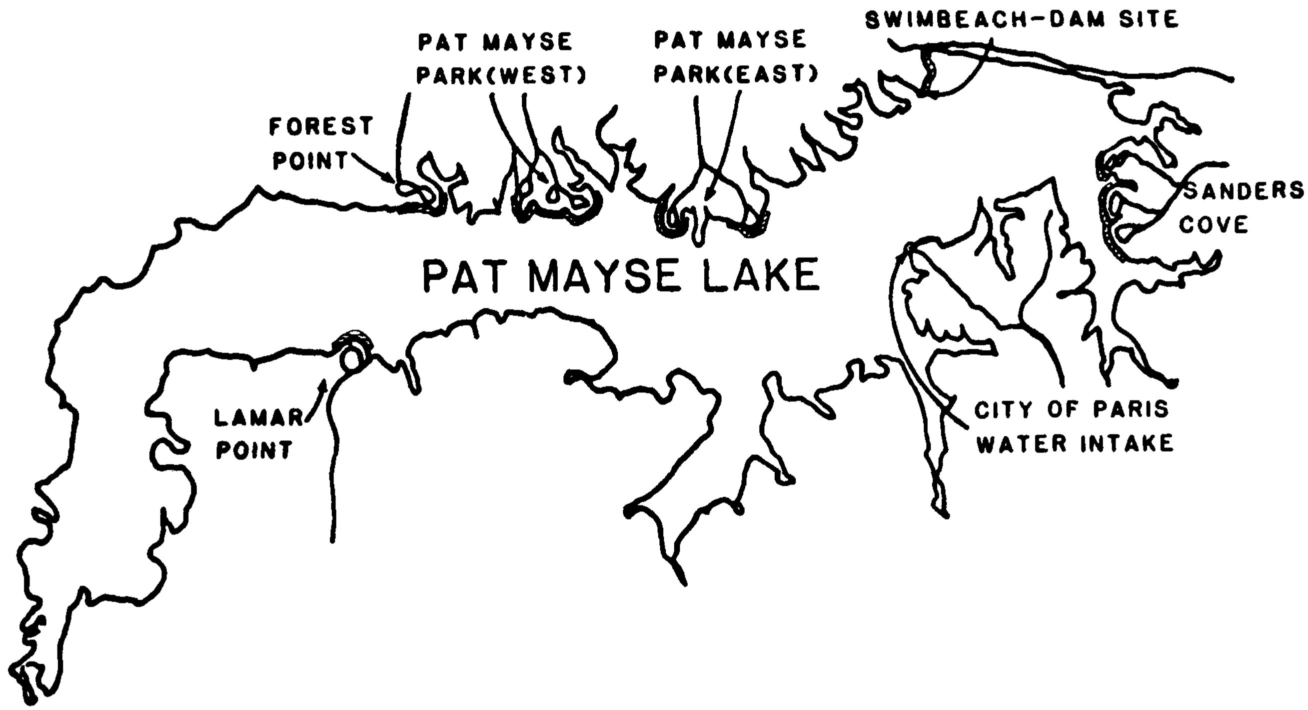

Figure 3. Seven sites in Pat Mayse Lake monitored for water quality parameters and endothall. Shaded regions indicate sampling areas

e. Plant material removed during a harvest operation may be transported to a suitable dumping site or disposed of in the lake. The lake disposal site is the chosen one at this time and will be monitored when implemented.

f. Pat Mayse Lake is an ideal habitat for watermilfoil and other rooted, submerged aquatic plants, and can be expected to periodically achieve problem proportions in this reservoir.

g. Measured sediment accumulation rates in Pat Mayse Lake ranged from 0.22 in./year to 1.49 in./year. Sanders Creek loading contributes about 50 percent with the rest attributed to bank slumping and in-lake production.

h. Water quality in Pat Mayse Lake remains good. The lake is characterized by relatively clear water and much of the nutrients are contained in the sediments. There is no evidence of an increase in nutrient content of the water over time. Nitrogen appears to be the element limiting watermilfoil growth in the lake. The euphotic zone of the lake appears to be approximately 2.5 m, suggesting that watermilfoil may be unable to grow below that depth in Pat Mayse Lake.

i. There are three efficacious outlets for information and for involving the public in management decisions on Pat Mayse Lake: (1) direct information to lake users via handouts, posted notices, or project personnel; (2) local radio and newspaper announcements or news releases; and (3) special efforts to communicate with interested groups, such as talks with bass clubs and civic clubs.

FUTURE STUDIES AT PAT MAYSE LAKE

Pat Mayse Lake is a valuable water resource that warrants careful management and can be expected to change with time and use. To ensure an adequate update of information, surveys at a frequency of about every 3 years will be initiated to define the rate of change and to potentially allow anticipation and efficient management decisions regarding water quality and aquatic vegetation control.

The ultimate goal of the Pat Mayse Lake studies is the production of an operations manual for the project to include methods and procedures for monitoring, and control and management planning of the major categories of concern (aquatic vegetation, water quality, and useful reservoir life) to the Tulsa District. If funding permits, this manual will be developed and completed in 1986. The manual will serve the purpose of technology or information transfer and will provide a common document for both the field and District Office in determining future management control decisions.

ACKNOWLEDGMENTS

The author wishes to acknowledge the exceptional work performed and cooperation received from Dr. John H. Rodgers, Jr., and graduate students under his supervision from North Texas State University, during the past 4 years.

CORPS DIVISION/DISTRICT OPERATIONS PERSPECTIVES

Southwestern Division, Forth Worth District

by
Edward Moyer*

The Fort Worth District has had a long-term annual aquatic weed maintenance spraying program at Sam Rayburn Dam and Reservoir and at the considerably smaller sized Town Bluff Dam - B. A. Steinhagen Lake. The projects are located in the deep east-central Texas region and are linked together operationally via the Angelina River discharge out of Sam Rayburn Dam which enters the north sector of the Town Bluff Dam - B. A. Steinhagen Lake. The spraying operations have been ongoing for many years now, although the total acreage treated at both reservoirs has been considerably reduced (to approximately 500 acres per reservoir) over previous years. Natural and operational drawdowns (the latter not specifically done for aquatic plant control) have had much to do with this reduction. For the last 10 years or so the mode of application of herbicide to the principal aquatic weed problems (waterhyacinth and alligatorweed) has been spraying from a fully equipped boat rig with an approximate treatment area of 20 acres per day over the period of any one recreational year (April to September of a year). The contract for the aquatic weed spraying work has been with the Texas Parks and Wildlife Department under a 70-30 cost-sharing agreement, with the Corps supplying 70 percent of the total cost of operation, the state 30 percent. Mid-term and final inspections of the areas treated are made by both agencies in the field to ensure that work is progressing reasonably, in terms of areas and amount of acreages treated. We see no reason to change this type of contract.

We are enthusiastic about the possibility of the introduction, into Texas, of the herbicide SONAR or its equivalent. In fact, this has spurred new interest into our assessment of works that need to be done at other reservoirs. This is especially important due to the insurgence of hydrilla into many lakes and reservoirs in Texas. We have made contact with all project managers and staff at all District reservoirs as to their need for treatment of any critical submerged aquatic weed problem. Of all reservoirs contacted, we were able to pick up only one additional reservoir that had such a problem, this being Lake O' The Pines in northeastern Texas. Most project managers had no critical submerged aquatic weed problems, again primarily due to lake fluctuations. Most reported small acreages of waterlilies, lotus, and the like.

We have noted the new 70-30 cost-sharing contract recently initiated between the Galveston District and the Texas Parks and Wildlife Department. The key item in that contract is the all District-wide or all-inclusive "location of work" phrase. We

* US Army Engineer District, Fort Worth; Fort Worth, Texas.

are undecided at this point whether or not this would be appropriate to our situation. We do not have monies enough to cover an all-inclusive clause now, nor do we have a majority of projects with any critical need for aquatic plant control. As it stands, we are getting ready to renew our 70-30 cost-sharing contract with the Texas Parks and Wildlife Department and although we will include a new project site (Lake O' The Pines) in addition to work to be done at Sam Rayburn and Town Bluff, we anticipate going with the original Galveston contract previously used. Should a problem develop unexpectedly at any reservoir not specifically sited under the upcoming contract, we will attempt to get that aquatic weed problem covered via an amendment to the basic contract. Should such a time develop when we are looking at predominant aquatic weed problems at a considerable number of the total reservoir sites within the District, we may go with the new inclusive Galveston contract format (and if the monies become available). For the upcoming 1986 recreation year we have allocated $12,000 and $16,000 for work to be done at Town Bluff - B. A. Steinhagen Lake and Sam Rayburn Reservoir, respectively. This will treat from 450 to 500 acres per reservoir. The Lake O' The Pines commitment is not definite yet, but we are most likely looking at a $10,000 commitment to treat approximately 35 acres of submerged aquatic weeds, primarily watermilfoil.

On a recent radio show, a noted bass fisherman, winner of many tournaments, was the main guest. He fielded questions from the general public. One caller asked what he thought of the proposed hydrilla spraying program for one of the nearby lakes. Need I supply this answer? No. "How dare they?" If anyone has passed a seine through some submerged aquatics in the littoral zone of a reservoir, one can see the distinct advantage of that vegetation as safety and harborage for small game fish species. One of the biggest reasons for people visiting Corps reservoirs is fishing, and certainly aquatic vegetation, especially the submerged weeds, are a distinct aid to their fishing success. Hopefully, there will be available a balance on aquatic weed treatment between what the fishermen want and need, and what we think is our obligation and duty to treat.

OPEN FORUM: WHERE DO WE GO FROM HERE?

Lewis Decell: You have heard a history of the program, and you are already aware of the technical aspects of the program and some of the thoughts we have for the future. Now we are interested in finding out what you think about areas that we should address. Recently at an integrated workshop, I made a comment addressing the problem of communications and feedback in general. I sensed a problem with the fact that when the Operations Support Center is doing the function they are doing and doing it well for the other Districts, that there were some missing links that were not being addressed.

If we look at the recurring types of requests that come from the other Districts to the Support Center, the redundancy flags an area that we may not be adequately addressing. The second point I wanted to make is that when somebody calls the Support Center for help, Jim asks what kind, and then he gives it to them, but nobody else learns from that assistance. My point is that unless you are asked and you get involved in that flow of information, you will not know what happened and you will not have that information at your disposal when needed. My third point is that there is a responsibility for our researchers to be responsive to the field's needs. There is a link between developing technology and providing a capability. The researchers do not know what the District is asking the Center to do on a daily basis. Therefore, the researchers are missing the identification of a need that should be addressed, possibly through research efforts.

What I am going to do now is ask that some of the District personnel stand up and tell us whether these are real problems. If we set up a structure to address these problems, what kind of mechanism should we create to do it?

Jim McGehee: We recognized this problem with the Center back at the beginning. In fact, one of the conclusions in our 1982 presentation was that we would be presenting some of these proactive-type things such as newsletters and all that. We need to be transferring information from one person to another. It is something that is needed, but it is one of those things that gets backburnered. As far as the research goes, I hope that we have been objective enough. I have to again point over to Vicksburg with the situation they have that when items come to us that we feel we can get to the researchers where it more appropriately needs to be there, we do everything in our efforts to direct them.

Mr. Decell: You have. And you have done a super job of that, and I think we have done the same thing going the other way.

Mr. McGehee: I would like to hear from the other Districts as to the way they feel. It gives me a feeling of satisfaction to be able to help people around what appear to be very difficult or impossible hurdles that have some simple solutions. That is one of the things we can do. There are a number of other things we can do, and these things probably should be shared with everyone. We have done a lot of the groundwork to get some of this going, but right now, we do need additional resources.

Mr. Decell: We have reached a point where we have identified a potential need. Jim is all for it, and he is willing to do it. He needs some resources. So can we get somebody to talk about some mechanisms by which they would like to see this information transferred, and we could set up a system, and then we will put the monkey right on the back where it properly belongs for providing the resources to get it done—OCE.

Loren Mason: When this subject first came up, it occurred to me that we had lots of people with lots of different programs all over the country, but we still had a basic problem of communications. And I do not know that it is possible to load Jacksonville down unless they get added staff or added support. I would like to see that there be some time allowed in these meetings, for the operational elements to get together as a group in a working session where we could talk about operational problems, and we could address things to Jim that we feel are coming up in the next year or two. I think the program managers should monitor this session and put it all down on paper so that when it is all finished, it could become a part of the total program. In other words, it is something that comes out of the Aquatic Plant Control Research meeting, and it is something you could take back to WES and say, okay, how can we fit into this part the operational folks are needing and what part does Jim need to support. It seems to me it is a little unfair for me or anybody else just to pick up the phone and call Jim and say, "Jim, I got a problem, I need this help and this help," because Jim's got to sell it to his boss, and it is tough when you have to sell things to your boss. He does not think it is priority. He is busy with other things. I understand all those things, and I think the best mechanism is for the emphasis to come out of the control program here with our tech monitor who is aware of what some of the operational concerns are. He knows before he goes back to OCE what the operational folks need.

So I would like to suggest that some time be set aside at next year's meeting for operations people to meet. This means that operational people need to come prepared to contribute. Do not wait for somebody else to tell you what to do. Do not wait for Lewis to tell us to get us started. We know what our problems are. We know what our needs are. We should come prepared with a priority list for our Districts, so we can anticipate problems for next year or the next year or three years down the line. And here is the help we need. We should be prepared to make this work so that we do not sit here with our hands in our pockets and everybody looks at everybody and nothing gets done. If we are going to ask them to do something for us, then we have to be willing to communicate back. Now, whether the information that comes out of the Aquatic Plant Control Program at the end needs to be put in some kind of a tech note publication, I do not know. But I do know that if you have the information, you know what we need, it should be able to be acted upon better than what is happening now.

Mr. Decell: Everyone knows about the Civil Works R&D review that we have at the end of this meeting. What we need is an operational program review of the researchers here. Out of that review should come a report to be included in the proceedings and, if it is done early enough in the meeting, we can arrange for the annual chairman of that group to give a verbal report to the entire group on the significant things they discussed. And if you rotated the chairmanship each year, everybody would be accepting their share of the responsibility eventually and

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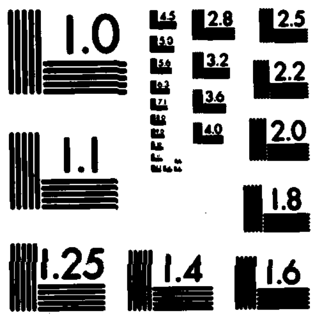

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coming to grips with knowing what all the other Districts are doing because they would have to be the reporters.

Mr. Mason: We need something to tie us together. You know, meeting once a year is great, but after we all leave this meeting, go back to our routine, we get wrapped up in our daily jobs, and we probably will not think about this program again till next year. And that is a problem; it does not answer the problems we have, and we keep talking about the same thing year after year after year.

I think this open forum is one of the best things that has come about in this program since I have been a part of it since '75. I would encourage that we include an hour or so in future meetings for an open forum. This is a real opportunity for exchange directly between operations and research. It just gives people the opportunity to speak up on matters of concern.

Julie Marcy: The Vicksburg District is fairly new to the problem of aquatic plant control or aquatic plant management, especially in a reservoir area. We have just combined with project operations, and we have been doing work around levees and weirs and pumping plants and so forth. But it is so new, and it is just a very small portion of what we are asked to do. But as a newcomer, as a beginner, we were essentially totally in the dark, whether it was out of our own ignorance or the fact that we do have so many other jobs to do—whatever the cause, we were in the dark. We did not have any information. We were very fortunate that we have Jim McGehee and the folks at WES available. They were very, very helpful. I think the Center did a terrific job. In our first little venture forth, we did not succeed. I think part of the reason is that you are dealing with Mother Nature, and there are no absolutes and no absolute control measures. But we can improve that. What would have helped us is to not only go from here on and be kept informed of what is going on, but to take a step backwards—conduct a computerized literature review. We need case history information—what the problem was, what treatment was used, what the results were—long-term short-term effects. What I am talking about is finding out what has already been done, consolidating the past efforts at the Districts into an easily understandable, easily used document that we could all benefit from. Whether you publish the results in a technical bulletin or a specialized report, just so long as a year-to-year update is provided. A form could be sent out to the Districts prior to the annual meeting each year asking, what did you do, what was your problem, how did you treat it, what happened, etc. Very simplified. I think most of the operational people would take it as just that—a simple cookbook outline, not a detailed discussion.

Mr. Decell: Like a reference manual.

Ms. Marcy: That is right.

Mr. Decell: Looseleafs that could be updated.

Ms. Marcy: Just some basic info so we could ask intelligent questions and avoid some of the Corps' decentralization—keep us from reinventing the wheel time and time again. This is one case in which we could really use a great deal more information exchange.

Joe Joyce: I have really enjoyed these comments because Lewis, Jim, and a few other people and I sat down, and we established the Center. We took a gamble. I had someone tell me after it was established that we were crazy because it is a bureaucratic rule that you never take on additional responsibility without additional resources. Jim and I knew that going in, but we said, let's do it. Let's bite the bullet. If you do a good job you will be recognized, and you will get the resources. What I am hearing today is the crapshoot of 5 years ago is finally going to come to fruition. For me, personally, it is very rewarding to hear the comments that you have been making. I have got two points to make. We are talking about integrating control. And people say, well, integrating control, that is not the word we want to use. I agree. That is not the word because it sounds too much like you are dealing with a specific agricultural crop in a given area, and you have got to control everything that happens in there and base what you do on acceptable economic damage to your crop. The comment that Julie just made about going back and documenting what you do, the St. John's River is a prime example of sitting down and thinking through a problem and coming up with a solution. I wish I could stand here and say we came up with that plan and that diagram before we did it. We did not. About two years later, we sat down and said, now how in the world did we do that. The point I wanted to make, rather than call it integrated, it is really a system we are dealing with. So for lack of being corny, SAP then, Systematic Aquatic Plant Management.

Mr. Decell: We have trouble repeating our successes, maybe because we are not documenting the successful experiences or, at least, our level of expertise at that time, and in a timely manner to share with everybody else.

Mike Eubanks: I would like to pick up on what Julie said about reinventing the wheel. After 14 years of coming to meetings you see new Districts or problems, particularly submerged aquatics, being spread nationwide now. Districts that have never experienced problems before are now having an instant overnight hydrilla problem or milfoil problem or whatever and are having to go through the whole process of developing NEPA documentation, contracts, or cooperative agreements. A vast bank of data is available that Jacksonville District and New Orleans District have put together. The need to document historical stuff is great. The idea of the looseleaf tech notes, like the dredging program has at WES, seems to be a very appropriate, very useful idea. Organize it into mechanical, biological, or whatever; I do not think you would be able to include everything, but just have a person go to the various Districts, and go through all the previous WES publications, and summarize them in an annotated bibliography, a brief synopsis of what that work involved. There is a lot of information documented in the files and it would be useful to dedicate a person to go in and dig that out and put it into some kind of brief computerized summary that would be available nationwide and that could be updated. For someone like me, who has to sit behind a desk and is not out behind a spray nozzle all the time, some type of newsletter would be real helpful.

Also, we used to take field trips during the annual program review; I enjoyed those in the past because they gave me a different perspective because I was going into a part of the country that I was not familiar with. I always found that useful to see what the weed problems were or what the areas looked like, plus the conversation on the buses out and back was always rewarding.

Julian Raynes: I would like to remind the group here of a team of two or three people that went around to every Division and every District and sat down with members from that office for a period of two or three days and discussed their problem. It was just a general open discussion. This may be a way of setting up a past history with each District and Division. This may be a beginning or a way of getting something down on paper to start this two- or three-man committee to go out and talk to all the Districts and Divisions and then come out with a short report. And, one other item, in the old days, we used to have to come up on the budget justification and say what we did last year and what the successes were last year, what we hope to do next year. This was tied into a budget request. That in itself is a past history, and if it could be worked up a little bit more in detail, it might be just what you are looking for.

Joyce Johnson: For the past 20 years, the research program has done excellent work, and no one relies on it more than I do. But they have all the resouces. They are always out in the Districts. It seems like the resources need to be made available to the operation people because that is the real concern. Jim has helped me in the past year. There are solutions to problems I have that I have not even dreamed of, such as the cooperative agreement. I was trying to work out a contract when there was a whole new solution out there that would have met all the problems I had. It seems like we need more resources for Jacksonville.

Mr. Decell: The Center was never staffed with the people that it was originally designed for. Now that is a personnel problem, and you cannot blame Carl Brown or anybody. It is the system.

I would like to see as an optional way of helping Jim get some more resources that you think of an organizational structure of the Center that reaches out into the regional areas and formally tags people as experts and puts their names in the notebook; for example, Bob Rawson for Pacific Northwest—things that he is more familiar with that may relate closer to your problem; for waterhyacinths and things southeast Jim can coordinate. This way Jim can get help from a team of experts.

Mr. McGehee: I refer a lot of people to Bob Rawson because he has recent experience and he is very well aware of some regional things. One of the major things I try to do is refer people with problems to somebody that will give them a good answer.

We prepared a notebook for Carl last year with contacts for the aquatic plant control for all Districts and Divisions. If you do not have one, or if you are not on it, let us know, and we will take care of it.

Carl Brown: It is a complete and very good list. It has the addresses, the office location, and the telephone numbers of all the people who have direct responsibility for the aquatic plant control programs in all of the Districts across the country. How many of you have access to something called the electronic mail system or electronic bulletin board? Within the Corps people, how many of you do not? How many of you use it? This is one of the most expeditious ways of finding people who can help you with a problem. You can get on that system, and you can say to every District and every Division in this country, "Attention aquatic plant control program coordinators; I have a problem in X, Y, and Z.

Who has experience in these areas?" And you would be surprised at the response off of this system. I know this is not the panacea to all of our problems, but I just wanted to be sure that you were aware that it exists. It is certainly an answer to the first step in dealing with the kind of things such as where do you go to get information. That is certainly a start. My message is, let us be sure we use what we have before we start screaming panic.

Robert Rawson: The on-time electronic mail system is set up for REC resource folks, and we use that a lot. Maybe that same system is the one you end up using for the aquatic plant inquiries. Would that be correct?

Mr. Brown: That is correct. However, I am confident that the people in the REC resources units would be more than pleased to get any information to other people that do not have access or immediate access to the system. The responsibility for the program varies. I do not know by what percent, but I would say probably about 50 percent in the planning divisions and about 50 percent in operations. But the lines are so close in terms of the types of responsibilities in this particular program with national resources management, I do not see a problem. Even if you are not in natural resources, if you will let them know that you want to use their system for this kind of an information exchange, they will help you.

Dave Haumersen: What is the source of getting one of those contacts for all the aquatic plant control people?

Mr. Brown: Operations Support Center. And if you will just give us your name before you leave and say, I do not have one, get it to us, we will be sure that you get it. He was asking about the source for the list of aquatic plant control program personnel. If you want one and do not have it, just be sure that we know about it before you leave.

Mr. Rawson: This meeting every year provides a great amount of information on what other Districts are doing, what problems they are working on. We get a lot of contacts, names, and phone numbers. But it is a year between meetings. The proceedings come out probably about close to a year after the meeting. I would very strongly support some type of information exchange during the year, a newsletter from Jacksonville, from OCE, from whatever source. But I think we need something to fill the gaps between the meetings.

Mr. Decell: We have an officially approved information exchange bulletin that was started several years ago. At every annual meeting I have encouraged everybody that if you want to put an article in there, all you have to do is get it to us. We will have it typed up, printed, distributed, and at no cost and effort you. And I have not had one article in seven years from anybody but the researchers. And some of them, they are so busy, it was like getting blood out of a turnip. So the mechanism's there is what I am saying.

Mr. Rawson: I have read yours, and I do associate that more with the formal research programs.

Mr. Decell: If you want, we can change the face of it so it will look more both sided, and we can start utilizing it. I would like to see nothing better.

Mr. Rawson: You probably know a lot that is going on around the country, but you are not aware of the interchange between Jacksonville and the different Districts. There is a large communication problem. Something to fill the gaps between the annual meetings would be very much appreciated by our District.

One other point. We receive a lot of calls from different Districts. We received three calls within a week from Baltimore a couple of years ago. The three people that called did not know each other. But I do not mind getting phone calls from around the country. We will help out people as much as we can with what we are doing. I hate to pass the buck. When people from the public call me, I do not like to say, call this guy, and leave them; instead, I use the three-way hookup on our telephone. I just tap the guys in, and we have a three-way conversation. It works very well, and the guy does not think he is getting passed around and trying to just get rid of him. That works very well; I use it a lot.

Ron Pine: The District workshops that Loren was talking about, I would strongly suggest that you include the state sponsors in the workshop arrangement. It would be meaningful for us. That looseleaf questionnaire somebody suggested would be sent out to the Districts, and it should be part of the workshop. One of the things that I would include in that questionnaire would be observations of plant responses. Now, we had a situation this year where the milfoil in Lake Osoyoos never topped out. There was a lot of parasite growth on it. It just never went anywhere. And it would likely be that we would not have even treated it this year aside from the court case. How many other areas around the country experienced the same thing? In other words, was it a latitude thing? Things like that would be interesting to us. Why did it occur this year and not last year?

Mr. Decell: Do any of the Districts have any idea why more state sponsors do not come to this meeting? Do we not invite them?

Mr. Eubanks: For the State of Alabama, we have been rotating the meetings. One person will go to the Aquatic Plant Management Society meeting, and I usually come to this one. When we get back, we get together and chitchat. We both go to the local Aquatic Plant Management meeting. But we both find we are going to so many meetings.

Mr. Decell: Maybe that is the problem, Jim, in Florida—a travel-type problem?

Mr. McGehee: We have run into a situation in Florida: you have the Florida Aquatic Plant Management Society meeting, the National Aquatic Plant Management Society meeting, all the other chapter meetings, and this meeting. It would be nice to be able to go to all of them. We realize that the people in the field that are making the application and the people at the administrative level need to be at a certain number of these meetings. It helps in administration of the program, by helping them to understand what their place is and what the problem is. What we do is allow them reimbursement under our contract on a 70-30 share basis for them to come to these meetings. At first, we did it just for the operational people, 30 percent. So every three years, a guy gets to go. We

have just increased that to every other year, and half of their operational people can go. So every other year they have the opportunity to go to one of the meetings, find out what is the latest. As far as the staff at the administrative level for the state sponsor, we will cover them at one of these meetings on a routine basis.

John Carothers: In South Carolina, it depends on the circumstances at the time of the meeting. This time, they were just too busy Maybe they will be here next time.

Joe Kight: Awhile back—I am not going to say where I was, what Division, what District—but there was a 12-year resource manager, who asked me what a waterhyacinth was. It is not necessary for him to know what that is, but it sure is necessary for somebody on his staff to know. In the Mobile District, 20 percent of my time could be spent on the projects. What I am trying to do is set up a surveillance program. I meet with the manager or whoever is the most interested in this sort of thing, be it ranger type or whoever, as long as he is interested. I have set up a little dog and pony show with hydrilla and various things and, again, a copy of the Florida book, picture book, of the weeds. And if you get anything that looks like this or like a bottle brush or whatnot, then call me. We need somebody between the guy in the field and the guy who knows what to do. If we can just get the people to identify these things. If a spray of hydrilla shows up on a boat ramp, believe me, it is easier to take care of at that water ramp than try to fight 17,000 acres 10 years later. Looseleaf notebooks are a fine idea, but consider putting it on a computer. I think it will be used a lot more.

Mr. Decell: You mean on a floppy disk and circulate it?

Mr. Kight: Right.

Mr. Decell: On this communication thing of identifying plants, you have got to realize a lot of people like me had to learn to spell the words and identify the plants when they first got into the business. There are more and more newcomers on the scene who are coming in at the same level that a lot of us started, and we kind of have a tendency to think what Joe said, sit around and assume that the guy ought to know what a waterhyacinth looks like. And he is saying, why should I? I just got here yesterday. TVA hired a firm to put together a videotape as a training aid to be distributed to the field. The tape would tell them what the plants looked like and what to look for. The study TVA did found that the normal retention of a crowd like this is about 25 percent. But, 82 percent of everything shown on the tape was retained. That is a very significant increase. So that is a thing that we might consider.

Okay. I think if we could shift gears just a little bit, and give somebody an opportunity to stand up and maybe give their opinion or ideas about research needs or research areas.

Mr. Joyce: People are learning how to control aquatic plants, how to manage aquatic plants, and, at least in Florida, 85 percent of all aquatic plant control activities are done with herbicides. We are reducing the amount of herbicides we are having to use, and we are dealing with a commercial market with agricultural products that corporate directors of those companies are looking at

expanding sales. And everything we do to get better at what we do, we reduce the amount of herbicides we are trying to use. That is the whole name of the game—reduce the amount of herbicides. So what it is going to come down to, especially as the state and local governments start having more input into labeling requirements now that they will not take EPA's word anymore, is the states labeling the products. The State of Florida is starting to label its own products, and California already does. There is going to have to be some mechanism for somebody at the national level to pick up some of these data requirements that are going to be required. It may even be that maybe the Corps or somebody is going to take a label and put it on a manufacturer. I hope it never comes to that, but I think this is something you have got to be looking at down the road. So I guess we are talking about some residue data.

Lars Anderson: I am not too worried about the problem of reducing chemical usage. The market's there because if you take a product that is being developed, such as Oust by DuPont, which is applied at ounces per acre instead of pounds, they are just making up the difference by raising the cost of that product. So I think the market is going to take care of itself. If you get real efficient and go down to 50 percent chemical control, those compounds are going to cost you more to use; that is just reality. You are going to have less of those in the environment, and that is good.

We have been having to gather residue data for the last 25 years. That's really nothing new. The real threat is the more emphasis on what is happening in the groundwater contamination. So I think that is going to be a big effort. It is already started in California, and probably the most notorious case is the selenium problem, but it is going to encompass the other organics as well.

The other comment I will make has to do with future research in terms of allelopathy and competitive plants. What I would like to see is some more comments on approaches by using beneficial species. The spikerush has been used in the west experimentally for some time. But it is only one of several that could be used. And I am wondering if, within the Corps' program, there is going to be an emphasis on exploring from the level of identification of potential species or whether it is going to be primarily looking at those that have been already identified as potentially beneficial species, such as spikerush. Is this program going to look at beneficial plants, potential allelopathy?

Ed Theriot: We were talking yesterday about new directions in our biological program: allelopathy and revegetation. The purpose of this new work unit is to work within the system. We are attempting to take some of the beneficial species and revegetating, or vegetating areas that have the potential for infestation with problem species. We do not intend to concentrate mainly on allelopathy, although that will be one aspect. We hope to do a thorough literature review and put out a document on the feasibility of such an approach. We would definitely touch base with your research facility. We know Dr. Sutton in Florida is doing some work with it, as well as several people in academia. We are going to take a holistic approach to this thing and hopefully put out a document with a test plan this first year to give us some direction.

Mr. Decell: Any comments on that area? Anybody want to bring up any other areas for discussion?

John Gallagher: One thing that bothers me is the feeling I get that you do not have a training session. We hire new people and we do not dare let them out in the field until we train them. In the course of the week, they may not learn everything they should know, but they know who to talk to. I think you ought to start thinking seriously about a training session, a period where the new people could be brought together with the knowledgeables. The new people are qualified for a number of things, but the most important thing for that particular District or location is that the new people know a little bit about what they are supposed to be responsible for.

From a research standpoint, there are always doors that can be opened, and the point that was raised of losing herbicides is real. You will never be without them simply because you will never get that proficient that you can do without them. It is conceivable that new and better ones may come along, but you cannot count on it. What you have got to do is begin to figure out how to refute the arguments raised by those people who are against the use of pesticides in water. In the next 10 years, contamination of water is going to be a point of concern to many people. The average housewife is going to be aware of the fact that somebody is contaminating the water because everybody, politician and right on down, is telling them that it is occurring. So we need case histories. You have a complete case history of what has happened to endothall. That has to be packaged, and we have to get more evidence so that we can, almost by the weight of evidence, convince and change some minds that the use of a pesticide is not a totally unreal concept.

As to reinventing the wheel. When you get as old as I am, we have done it all, we have seen it done. We may have done it twice ourselves, but we realize that this does occur. There is a change of people, and there is a learning process. We must begin to think in terms of making available the information already available, but we also must keep in mind that our prime objective is to maintain any mechanism we have to control and manage aquatic plants. We need every tool we have. We cannot afford the luxury of losing one. Find a way where these young people can at least be helped a little before they get started because the responsibility is there. The potential for making an error that makes the headlines is still there. And you have either a nondecision or a wrong decision if you do not help them a little on the way.

Mr. Decell: Thank you, John. Anybody else have any comments about research or operations or the program as a whole?

Mr. Mason: What is the status of the herbicide manual?

Howard Westerdahl: We are attempting to get a document out for review as a draft sometime during the early summer, and then hopefully try to get it to Lewis for publication later on.

Mr. Mason: So we should have it before the next aquatic plant meeting?

Dr. Westerdahl: No. I will say you should see a draft before then.

Mr. Decell: We will see the manual published.

Mr. Mason: Okay. I am interested in seeing WES put together a collection, consolidating available information on the life history of each of the aquatics identified as a problem. Things like phenotype, genotype, physiology, environmental controlling factors, all of the things that if there were some kind of a manual that could be made available to the Districts, that would be helpful in classification. The literature needs to be pulled together on the various types of plants so we are sure that we know that a certain chemical will do a certain job in a certain area. Because there are regional differences, chemicals will react differently and growth patterns will be different. I think there is a need, and WES appears to be the logical one to pull together that data. I realize that is a monumental statement, and it cannot be done overnight. But, again, that is something that I think an operational District like mine would certainly be interested in seeing.

Mr. Decell: We have not done anything about it except begin to discuss it among ourselves at WES. Maybe in the next few months we should convene a meeting and try to hash out just what is entailed in doing that effort cost-wise and see where it fits in. You are right, there is still a need.

Dr. Westerdahl: There will be a section in the herbicide guide dealing with plant identification. We will do as good a job as we can in getting photographs of the individual plants and a perspective and key characteristics of how to identify the plant and also some facts relative to geographic differences, relative to that particular species of plant. But we are tying into 55 or 60 major nuisance aquatic plants that the Corps has listed previously. Those are the ones right now that will be in that guide. So, though you may not see it in June or July, you will see it later on in the year for your review comments.

There will also be a section where the plants are listed, and each of the chemicals will be identified. It will be based on literature, as well as experience, as to whether or not those chemicals have been effective in controlling those particular plants. And, if not, why not. Hopefully, we can point out their geographical differences as well.

Another thing that comes to mind is that we need to better identify where the problem is. Just because we have milfoil or hydrilla in a given lake, we tend to want to treat the whole area, get rid of milfoil, but then we find out that hydrilla is coming in in its place. That may be just as bad. We found out in the Baltimore District that their objective was to make boat lanes rather than treat all areas. I guess we need a better perspective as to exactly what the Districts' objectives are in specific reservoirs: do we want to get rid of all the aquatic plants or only a portion of them? We need to identify how much or how many plants are necessary or good for the system, which ones we want to get rid of, how much is good, how much is bad, that type of thing. I think we need to pursue that as well.

Mr. Mason: I think Howard has brought up a good point. Within the Tulsa District, when we first started back in '75, there was a feeling we needed to eradicate the plants. That mentality has changed completely. By '78, '79, we were already thinking in terms of maintenance control. Now we are to the point of saying that the only control we are really concerned about is in and around high-use public areas. We are talking about boat ramps, swimming beaches, and shoreline areas

where there is a potential for the public to get into problems if they wade out into the plants. So we are talking about high-density-use-type areas. We are not talking about backhole areas anymore. Along the navigation channel, it is the same thing. We are looking at controlling areas that could tend to block navigation, but we are not worrying about sloughs and backwater areas. When I say we are not worried, that does not mean we are not cognizant of what is there. It does not mean we are not monitoring. It just means that to attack it just because it's there is no longer a mission of the District. Part of that has been brought about by the public's adamant feeling that they need the aquatic plants for fishery. That has been well stated by the Oklahoma Park Wildlife Conservation. They are very, very cognizant of the fact that aquatic plants are a big part of their fishery propagation, so at least from Tulsa's standpoint, we made the commitment several years ago that ours is going to be one of a maintenance program targeted towards high recreational use, and we will monitor the program as it goes along. And if we need to control, we will, but only in specific areas.

Mr. Kight: I keep hearing that you need hydrilla to have good fishing. I would like to see some good factual data on how much, where, what communities, and what locations are needed to really benefit the fish.

Mr. Joyce: The number one issue in the State of Florida right now is how much vegetation do you need for fish? We have gone in and intensely sampled lakes and tried to see what we wanted to know in one lake and apply it to all the lakes. We need to look at the whole spectrum of lakes—that is a major need.

Mr. Decell: Unfortunately, we do not have any data on that. And even more unfortunately, the people that we tried to work with in years past to come to grips with that in a quantitative way who are demanding that we leave all of this for the fisheries did not have any data either. And I always felt it was their responsibility to come to at least a level of quantification with us so that we could do a better job. It seems to be one of those things like to allow the use of chemicals: the environmental group can demand that we prove our point to the "nth" degree, but they do not have to have any proof. We have that same situation in some of these other areas. That does not relive us of our responsibility to do that, but it is an area we really have not addressed collectively.

Dr. Westerdahl: I just want to say one more thing. Relative to herbicide or chemical companies and new herbicide development, I think that we have been fortunate that SONAR, once it is registered, is probably the only chemical that has been registered specifically for aquatic use. I dare say that if Elanco could look back, they probably would not have made the decision to go ahead and get that product registered, simply due to the cost of registration, the ever-changing requirements for testing, and the time involved relative to that registration period before you can recoup the cost of development and get a profit out of it—maybe nine, ten years in some cases, and you are talking about a market potential of anywhere from 10 to 20 million dollars a year for herbicide use. So the dollars just are not there for a company to develop specifically for aquatic use. So most of the interest from chemical companies has been as spinoffs to another market. They are looking at this market as a potential way of accruing

some of their costs. I do not think we are going to see many more new chemicals coming down the pike because of the changing economic conditions, as well as the testing requirements from EPA and the states.

Mr. Decell: Mr. Brown, as technical monitor of this program, would you like to share a few comments with us before we close?

Mr. Brown: In my view, one of the more pressing needs of our program is to turn this thing away from the basic concept of aquatic plant control to aquatic plant management. We need to undertand better the total picture of plant ecology. Maybe the time is right for us to really take a move forward in this program and become aquatic plant managers. I have heard you say that we need a more sophisticated program. We need a better documentation of successes. We need better transfer of information about those successes and failures. Sometimes the lessons learned from failures are as important, and maybe more important, than the successes. You have told me—the operations people, the planners, not the researchers—that you need to better define to yourselves how to support Center and how WES can help you. I have been waiting to hear you tell us that. The regulation that covers the aquatic plant control program requires that we have a meeting such as this annually. The regulation does not say that it will be a research meeting. It says it will be a meeting to discuss research, operations, and planning requirements of the aquatic plant control program. I believe we are ready to break out of the woods on that one and put the operational facet a little higher on the schedule. And I am offering my services to Lewis right now to help more next year with the program agenda. I will do what I can to help us achieve that goal. As far as this session is concerned, I really believe it has been one of the more productive ones that I have attended. There is nothing as valuable in any program as feedback from the people who make it work. And that is you. And until we reach the point—and I think we have reached it now—where you are beginning to understand the problems and have the questions for us to deal with, we have not really arrived, but, I think we're getting there. I compliment Bill and Lewis for their efforts in this particular program. And Lewis is the genius that came up with the idea for this forum this afternoon. I think it was, in fact, a stroke of genius. Sometimes you sit back and say to yourself, hey, why didn't I think of that, I wish I'd said that. I guess that is the way we all feel about this particular session this afternoon and about this whole program. I am pleased to see every one of you take the time away from your busy schedule to be at a meeting of this nature. I know what a sacrifice it is. I am like you. The Aquatic Plant Control Program is one part of my duties, and I would like to believe that it is a small part. Often it is not. You, too, make sacrifices when you come to this meeting. You may even make sacrifices when you deal with it back at your home station. But the job has to be done, and in the Corps' tradition, as long as I am tech monitor or program manager for OCE, if we are going to do it, I want to do it right and do it well. And I elicit your support and help in achieving that objective. Let me just say again, thank you for coming, thank you for your input.

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